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ABSTRACT

Part of a geography series which stresses understanding of the environment through mastery of specific skills and concepts, the secondary level textbook investigates the interrelationships between humans and the goods they produce. The book is presented in 26 chapters organized around five main themes: (1) agricultural production, (2) manufacturing production, (3) difficulties that men of different backgrounds experience in living and producing together, (4) the relationship between living standard and health, and (5) interactions between men and specific environments. Cognitive, affective, and psychomotor objectives are listed in the introduction, and a final chapter suggests questions and activities for measuring student mastery of the objectives. Chapter format generally includes background information, illustrations, maps, graphs, and discussion questions. Some chapters also include learning activities such as library research, map work, essay assignments, and model construction. The major learning activities, however, are presented in the final chapter in which students are directed to apply analytic skills developed throughout the global system series to hypothetical farm and factory data. Specifically, students are expected to construct a map and systems diagram of the farm and factory from information presented, explain the layout of each site, and determine whether the uses to which men are putting the site are suitable in terms of suggested variables. (Author/DB)

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The Global System Level 3
PRODUCTION AND SPACE

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The Global System

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Introduction

TO THE STUDENT

By now you will have realised that geography is concerned with where things are and why they are there. As geographers, therefore, we are interested in looking at what happens at a particular place on the earth's surface, and in trying to understand why it is happening there and not somewhere else. These are very important questions; if, for example, we can understand why something unfortunate, like soil erosion, famine or smog, has happened in a particular place, we can plan to prevent this happening elsewhere and in the future.

Men are the agents for a great deal of what happens on the surface of the earth—they use the forests, they farm the land, they mine for minerals, they build factories in order to process and assemble materials, and they form cities.

Why do people do all these things? In farming and manufacturing, we try to produce all the materials that we need, or think we need—food, clothing, machinery, furniture, books and so on. Our understanding, then, of where these activities occur, of why they are carried on there, of the different elements that make up farming and manufacturing, and how these elements knit together, is important if we are to grasp fully the basis of our use of the earth's surface. When we try to understand why people do these things we have to consider so many aspects; water supply, temperature, soils and relief obviously affect farming —or are other factors more important? What affects manufacturing? In order to answer these questions we shall have to examine many other features of the earth's surface, some of which aren't so obvious.

Keep these questions in mind, as you move forward in your thinking about all these problems.

TO THE TEACHER

Production and Space continues the development of the concepts, knowledge and skills introduced in Levels One and Two of the Global System series. Level Three has been organised around the idea of production. Men produce goods from the land and from factories. We apparently need these goods in order to live. But in so doing, men affect other things that are a vital part of their life system.

It is thus impossible to separate completely one feature from another in the global system, and we anticipate students and teachers finding linkages between different ideas and concepts throughout the series.

Level Three, *Production and Space,* starts with the idea of studying individual systems—agricultural, manufacturing, social and physical. This is how the book has been organised, as you can see from the list of contents. Students will be able to study an individual system as it exists. Inevitably, however, questions will arise that force the student to consult other parts of the book. For example, a study of farming would be incomplete without consulting the section on soils. You will no doubt see many connections between a number of the different sections.

Thus in Level Three the main concerns are:

- Production of food in agriculture—what are the problems, methods and practices of different farmers as they produce food for themselves and the non-rural population? Are these practices satisfactory? Can agricultural production be increased, and at what cost to the life systems?
- Production in manufacturing—what do manufacturers and governments try to do in manufacturing? Are they succeeding? Do their activities have any other effects on the ways men live?
- What are the difficulties that men of different backgrounds experience in living and producing together?
- What is meant by 'being healthy'? What are the activities of men that bear on whether they are healthy or not?
- Men produce and live in drainage basins. How do drainage basins operate? What are the relationships between men and drainage basins?

All these studies are undertaken through the eyes of geographers as they attempt to understand the spatial elements of the systems involved and the way they interrelate.

As you can see, questions are basic to the structure of the book. To many of them there are no 'right' answers, but they are all questions that need to be considered for the future of the earth's

systems. Thus a valuable part of the learning activities that develop as part of using this book will be discussion and argument about the answers and the values that underlie them.

Parts of a book need to be presented in some sequence. The sequence in Level Three is largely arbitrary. We expect that different teachers and different students will use the book in widely various ways. We would be disappointed if this did not happen.

Objectives

Cognitive

1. Knowledge of the various inputs, elements and outputs of the farming system
2. Ability to apply this knowledge in the comprehension and analysis of different types of farms and farming areas, ranging from highly commercial to subsistence
3. Knowledge of the various inputs, elements and outputs of the manufacturing system
4. Ability to apply this knowledge in the comprehension and analysis of different types of manufacturing situations
5. An awareness of the difficulties men experience in living, working and being healthy
6. Knowledge of the inputs, elements and outputs of the drainage basin system, including the effects men can have in using the system
7. An awareness of and the ability to analyse the connection between the elements of all these systems
8. Developing further the geographical concepts of location, distribution, interaction, relationship and scale as they throw light on the connections between the various systems
9. The ability to learn by and for oneself by being able to comprehend and relate data, hypothesise from it, and then generalise, including the ability to carry out research from fieldwork, maps, statistics and written material

Affective

1. An appreciation of the way one thing may affect another thing—that one system may affect another system
2. A positive awareness of the need to study objectively such interrelationships
3. An awareness of one's own values in making judgments on situations and attempting to make values into a coherent system
4. A willingness to work with and listen to other people in a developing attitude to learning about oneself and the global system

Psychomotor

1. Map-making skills—the ability to produce maps (dot, divided-circle, other statistical, from vertical aerial photographs)
2. Ability to sketch landscape in the field and from photographs
3. Ability to use other graphic skills—producing graphs, divided circles, etc.
4. Ability to carry out surveys in fieldwork by mapping and using questionnaires.

1

Agriculture

From earliest times, man's greatest problem was the need to find food. First roots, berries and seeds were collected from the natural trees, shrubs and grasses, and animals were hunted. Eventually, however, men found that they could farm the land by planting seeds and harvesting the crops that grew. They also found that animals could be domesticated. And so people began to till the soil and herd the animals that provided food and clothing as well. *Agriculture* had been developed. This word is derived from the Latin language—*agri* from *ager* meaning 'field', and *culture* from *cultura* meaning 'care' or, 'cultivation'.

But man has always found it hard to find food in sufficient quantities, and in forms that provided enough energy to sustain life. People have constantly faced famine. For example, over a period of 2000 years there have been no less than 1800 famines in various parts of China.

The amount and the quality of food can be described according to the number of calories and the amount of animal protein it provides. Look at figures 1.1 and 1.2. The land shapes are unusual because the size of each country has been drawn in proportion to its population. Then each country has been shaded according to its food intake.

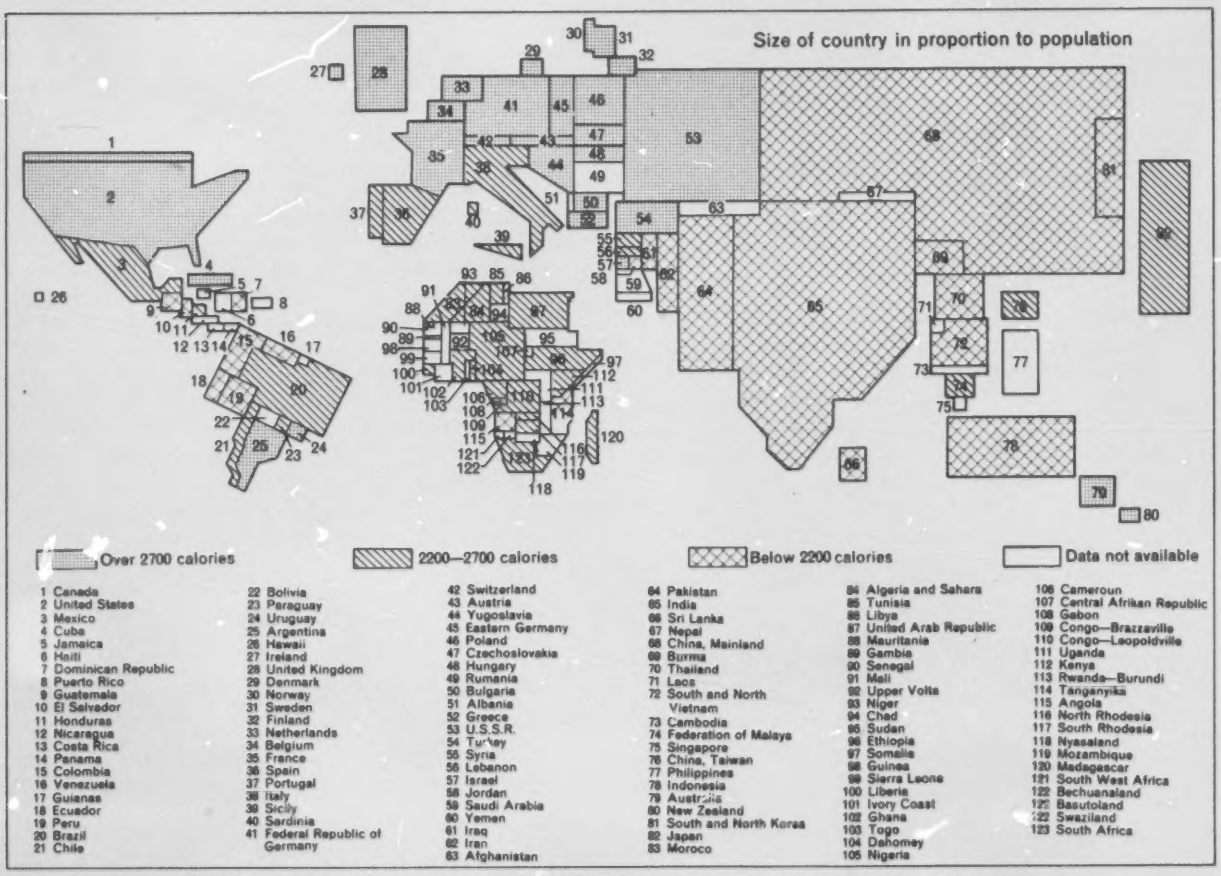


Figure 1.1: Distribution of the world's population according to daily intake of calories, 1962
*(Source: **Unesco Courier**, July–August 1962)*

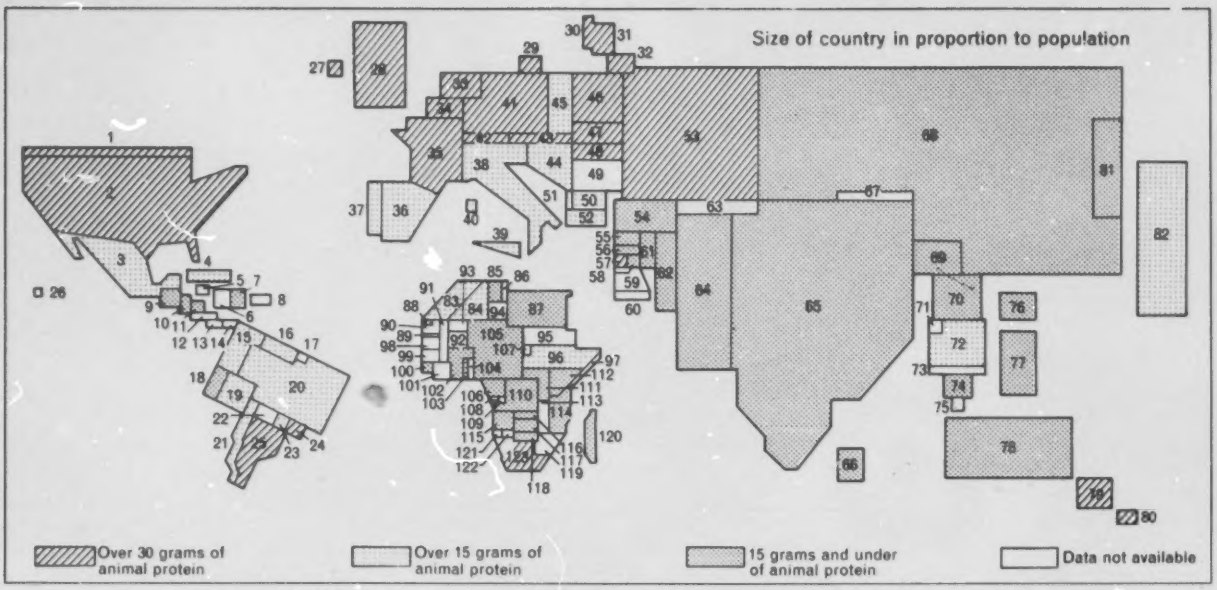

Size of country in proportion to population
Over 30 grams of animal protein
Over 15 grams of animal protein
15 grams and under of animal protein
Data not available

*Figure 1.2: Distribution of the world's population according to daily intake of animal protein, 1962 (Source: **Unesco Courier**, July–August 1962)—see figure 1.1 for key*

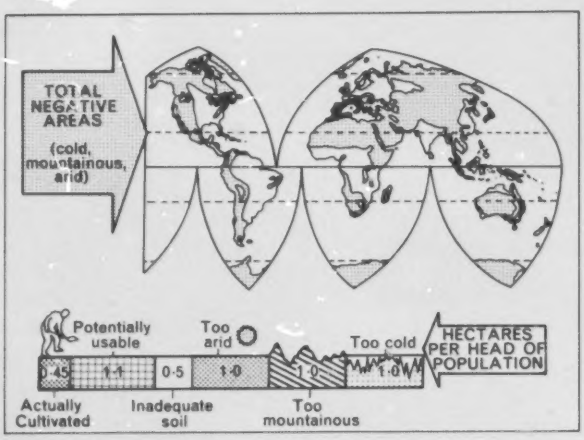


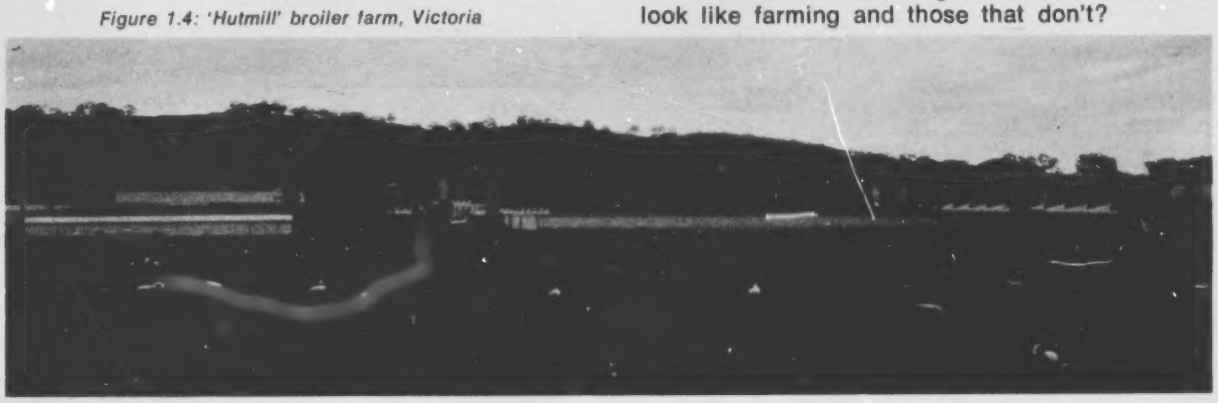
*Figure 1.3: The world's lands—total negative areas, and hectares per head of population, 1962 (Source: **Unesco Courier**, July–August 1962)*

What do these maps indicate about the distribution of food on the earth's surface? Do all men have an equal amount of food? Why can some farmers produce more food than others? A famous geographer, Professor Dudley Stamp, has suggested that one reason is that some countries have more 'negative land' than others—see figure 1.3. Another reason may be the wide variation in population among different countries (refer to an atlas map of world population density).

But what is farming? What do farmers do? How do they look after their fields? Perhaps the answer to this question will help us understand why some areas have more food than others.

Look at figures 1.4 to 1.12. Each shows a farm, or, more correctly, a piece of land where some form of agriculture takes place. As you examined the photographs, did you think they looked like farms? Which ones did not? What are the differences between those agricultural activities that look like farming and those that don't?

Figure 1.4: 'Hutmill' broiler farm, Victoria



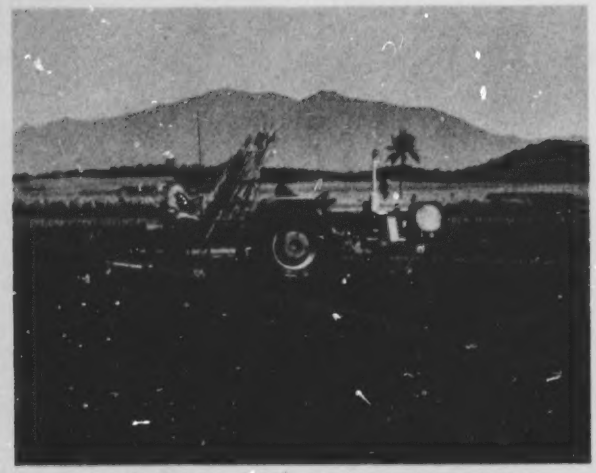


Figure 1.5: On a sugar cane farm in Queensland

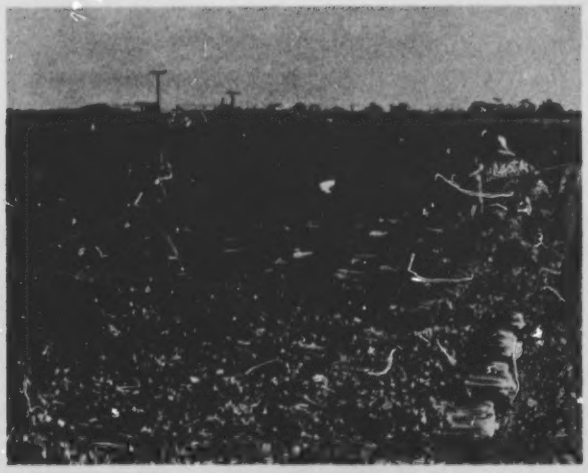


Figure 1.6: The old and the new—compare this scene of a market garden outside Adelaide with figure 1.7

Figure 1.7: A market garden near Pazardjik, Bulgaria. Many types of vegetables are grown in these hothouses

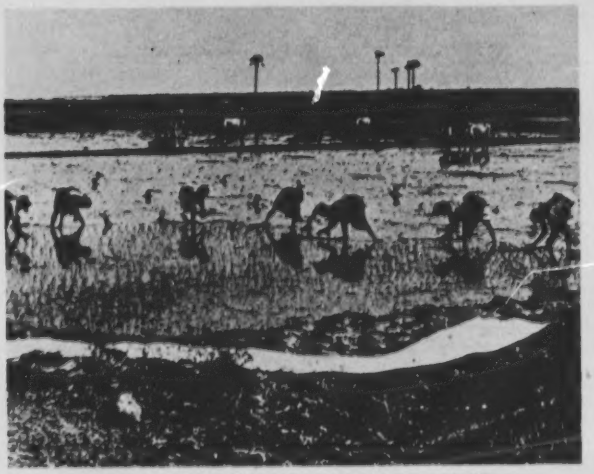


Figure 1.8: Planting rice near Madras, India

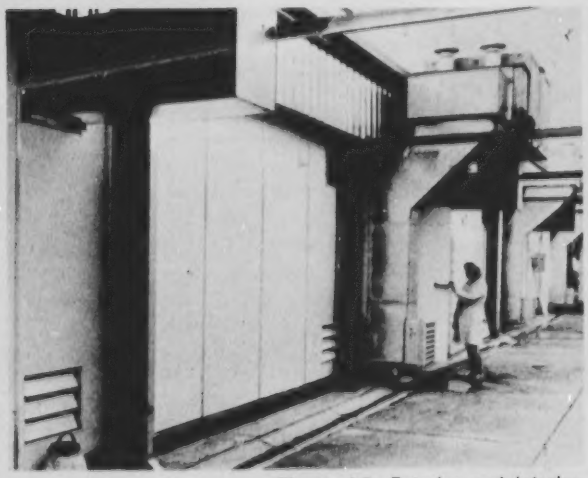


Figure 1.9: Exterior and interior views of a mushroom farm in Victoria

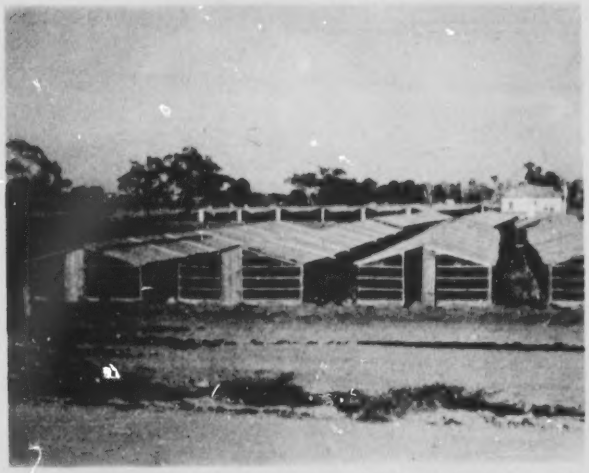


Figure 1.10: Glasshouse farming, Mildura. Compare this with figure 1.7

Figure 1.11: Note the combination of man, animal and machine in this fertilising operation on a farm in Ecuador

Figure 1.12: Harvesting cotton in northern Nigeria. What would be the problems of mechanisation in this situation?

Farming isn't just one simple activity, but a very complex business. How can we try to understand it? When you look at figure 1.13, how do you try to analyse it? You could describe it as it is now (*static*); you could compare what is happening now with what happened last year (*dynamic*); you could try to work out what crops, fibres or animals are being produced (*agricultural output*); you could look at the slopes, the soils, the climate and the vegetation (*biological and physical factors*); you might be concerned with how far the farm is from the nearest transport (*accessibility*); you might be concerned with how much work or money (for machines, seed, animals, fertiliser, and so on) the farmer has put into the farm (*agricultural input*). So you, as a geographer, could ask a large number of questions about farming, all of which would be concerned with thinking about why the farmer is farming where he is. All these questions give us a basis for understanding the farming system (figure 1.13).

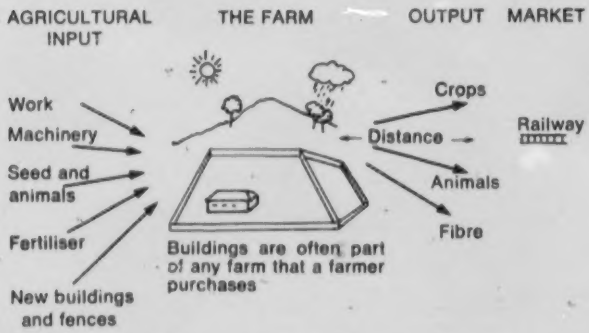


Figure 1.13: The farming system

However, a farmer is also affected by other concerns. What effect do you think the headlines in figure 1.14 would have had on wheat farmers?

A farmer, then, is also affected by who is going to buy, how much they are going to buy, and when they are going to buy. At least, this would affect some farmers. Which farmers, do you think, would not be so concerned?

You are now going to be able to read about and look at a number of farms and different farming types. Think about all these questions, and see what answers you can find concerning agriculture and its ability to produce food and other materials for men's use.

We lose $100m deal for wheat to China

An Australian Wheat Board mission to China has failed to sell any wheat. The board had hoped to clinch a deal worth nearly $100 million.

But the chairman-elect of the Australian Wheat Board (Mr. John Cass) said last night: "We are not very concerned at all. Our carryover will be the lowest for years."

He said the sale fell through "purely because they failed to agree on terms." He said politics played no part in the negotiations.

Asked last night how much the board had been hoping to sell, Mr. Cass said: "In line with previous sales, around two million tons a year."

[Two million tons is 74 million bushels — about a quarter of the Australian wheat harvest. Current world prices are $1.25 to $1.30 a bushel.]

The Wheat Board now expects a carryover in its silos of 123-124 million bushels. This summer's harvest, which has started in Queensland and the Mallee, was expected to be 270 million bushels.

Mr. Cass said the board had only forward-sold about 80 million bushels of wheat on the export market and expected the house market to take about 40 million bushels.

"Conditions may not be as buoyant as this year—it's the best year for exports we have had—but we expect to sell pretty well," he said.

"The latest forecast is that we will have a carryover at the end of next year of 90 million bushels. That's the lowest for years and years."

The board's statement—issued after a meeting in Melbourne yesterday—said the delegation's discussions in China were "on a most friendly basis."

The delegation was in China for about 10 days. Members were: Mr. E. Flegler (Queensland), Mr. T. M. Saint (SA) and the deputy general manager of the board (Mr. J. H. Williams).

In **Canberra** the Labor MHR for Riverina (Mr. Grassby) said last night that the failure of the negotiations denied Australian farmers the chance to earn much-needed income and foreign exchange. "We need all the trade we can get," he said.

He called for a permanent trade office to be established in Peking.

"At the pace we're going diplomatically and in trade we will arrive in Peking some time after the first visit by the Pope," he said.

• Australia's total wheat exports for the year ending November 30 are estimated at 325 million bushels—a record.

Under a contract signed in late 1969, China took 90 million bushels of Australian wheat between December, 1969, and early this year.

A political storm broke out between the Government and the Labor Party earlier this year over wheat sales to China.

In April it was revealed that Chinese officials told the British Consul in Hong Kong that China would take Australia's political attitudes into consideration in arranging future wheat purchases.

In July the shadow Minister for Primary Industry (Dr. Patterson), visiting China as part of the Labor Party delegation, said China had given preference to Canada because the two countries had diplomatic relations.

The Minister for Trade (Mr. Anthony) later blamed the Labor visit to China for Australia's failure to sell wheat to China.

Figure 1.14(a): ***Age****, 19 November 1971*

Wheat deal marks new era in trade

The recent clinching of a $600 million wheat deal marked the virtual coming of age of trading relations between Australia and China.

The trading opportunities between the two countries have increased at an almost unbelievable rate over the past two years. This has been highlighted by trade delegation visits to China and Australia.

The decision earlier this year to supply an extra $7 million in sugar to China under a new trade agreement was one of the high points on the upward trend in trade.

The wheat deal, announced recently by the Minister for Overseas Trade, Dr Cairns, made trading relations even firmer. Under this deal Australia will supply nearly five million tonnes of wheat to China over the next three years.

The Chinese have agreed to sign the agreement, creating the first long-term wheat deal.

Trade with China was only conducted on a minor scale until crop failures in the early 1960's opened up a market for Australian wheat.

Prior to this, Australia's trade dealings with China were virtually non-existent.

In 1959-60, exports to China picked up considerably through sales of wool with large quantities of wheat boosting exports a year later.

Since then, Australia's earnings from exports to China have reached more than $100 million on several occasions.

China's emphasis in trade has shifted significantly over the past 12 years.

In the early 1950s, the bulk of Chinese trade was with Russia, but since the 1960s this has steadily declined.

Japan and other Western European countries took over where Russia left off.

The Chinese attitude has resulted in a fairly unpredictable pattern of trading relations with other countries.

They place more emphasis on the needs of the economy in choosing markets, and far less on prices.

Agricultural disasters, from floods and other adverse weather conditions, play an important role in the need to import, or the ability to export.

The basic consideration is the needs of the 800 million population — roughly one-quarter of the world's population.

But Chinese trade is on the increase. In 1971 imports and exports totalled nearly $4000 million.

Total foreign trade usually accounts for only about 5 or 6 per cent of China's gross national product, but projections of the present rate of increase estimate a figure closer to 10 per cent by the end of 1975.

Australia rates fairly high on China's imports-exports list.

The top exporters to China at present are Japan, Germany, Canada, with Australia fourth.

As an importer, Australia rates about eighth, behind Japan, Germany, Britain and France. In 1972-73 Australia exported about $62.8 million worth of goods to China.

The emphasis was on wool ($16.7 million), wheat ($16.5 million) and pig iron ($9.8 million). Other prominent exports were sugar, iron and steel and tallow.

Australian imports from China for the same year totalled just under $50 million.

From China, Australia takes woven cotton fabrics, clothing and accessories, textile yarns and chemicals.

Trade relations between Australia and China have reached a new maturity, but so far only the surface has been scratched.

The visits to China by Dr. Cairns, and to Australia by Chinese Trade Minister Mr. Pai Hsiang-kuo, have set the pattern for the future.

During Mr. Pai's visit to Australia a wide range of trading possibilities were opened up—notably iron ore and possibly the Australian aircraft, the Nomad.

Figure 1.14(b): ***Australian****, 1 November 1973*

2

Food production in Victoria

The first set of farms to be examined in the following studies are located in Victoria and cover a wide range of types of agricultural production. Figures 2.1–2.8 show the distribution of a large number of types of production. When you study the various farms, compare their *location* with the *distribution* of their types of production. Use your atlas to compare the distribution of each type with the distribution of rainfall, relief, irrigation and any other factor that you think may be important. (Use especially the *Jacaranda Junior World Atlas* for Victoria.)

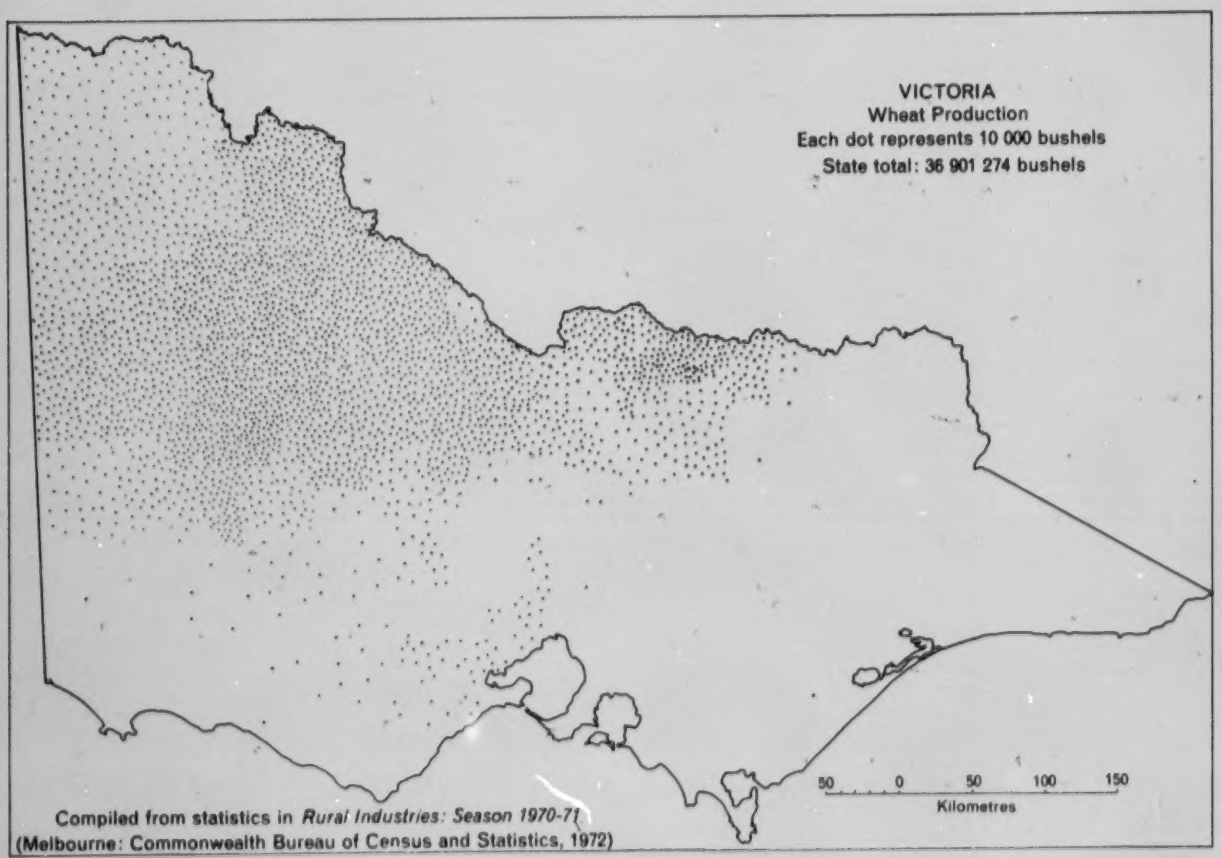

VICTORIA
Wheat Production
Each dot represents 10 000 bushels
State total: 36 901 274 bushels
50 0 50 100 150
Kilometres
Compiled from statistics in *Rural Industries: Season 1970-71*
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.1: Victoria—wheat production, 1970–71

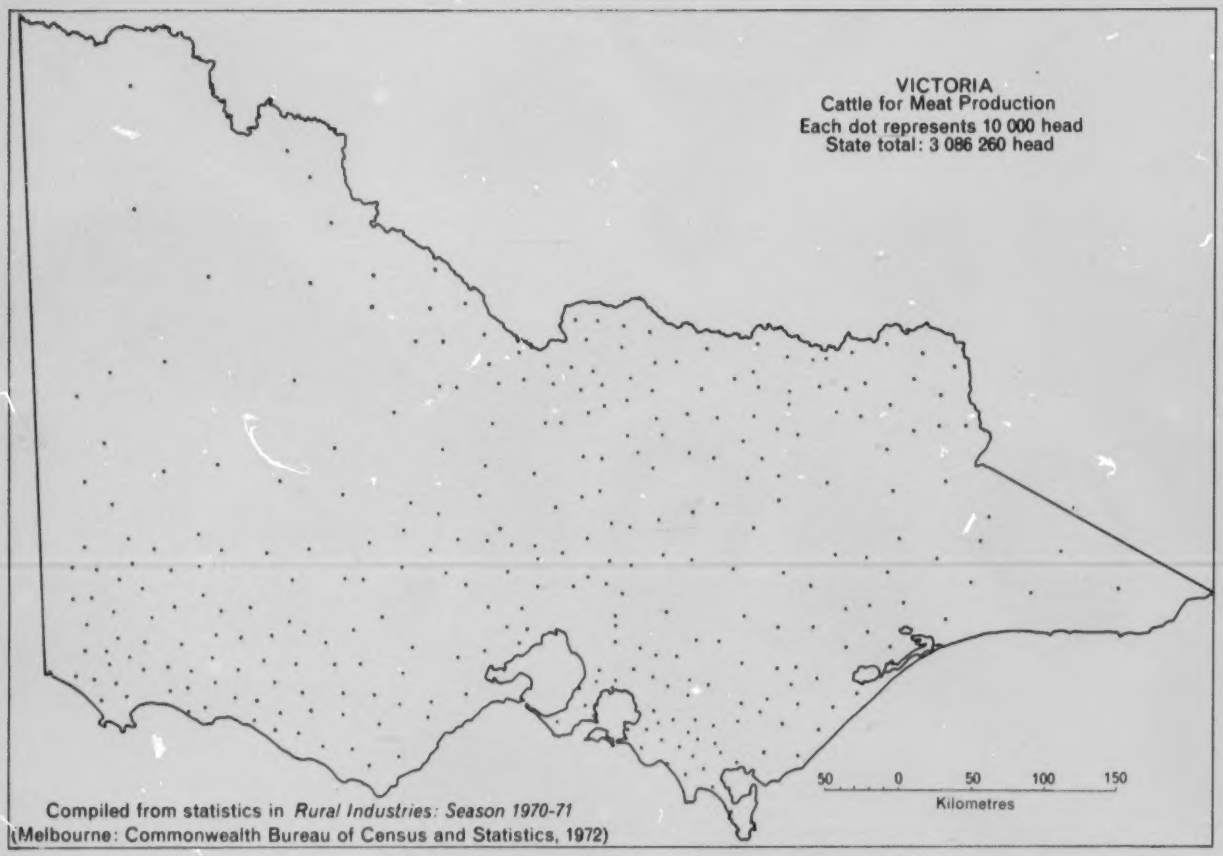

VICTORIA
Cattle for Meat Production
Each dot represents 10 000 head
State total: 3 086 260 head
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.2: Victoria—numbers of cattle for meat production, 1970–71

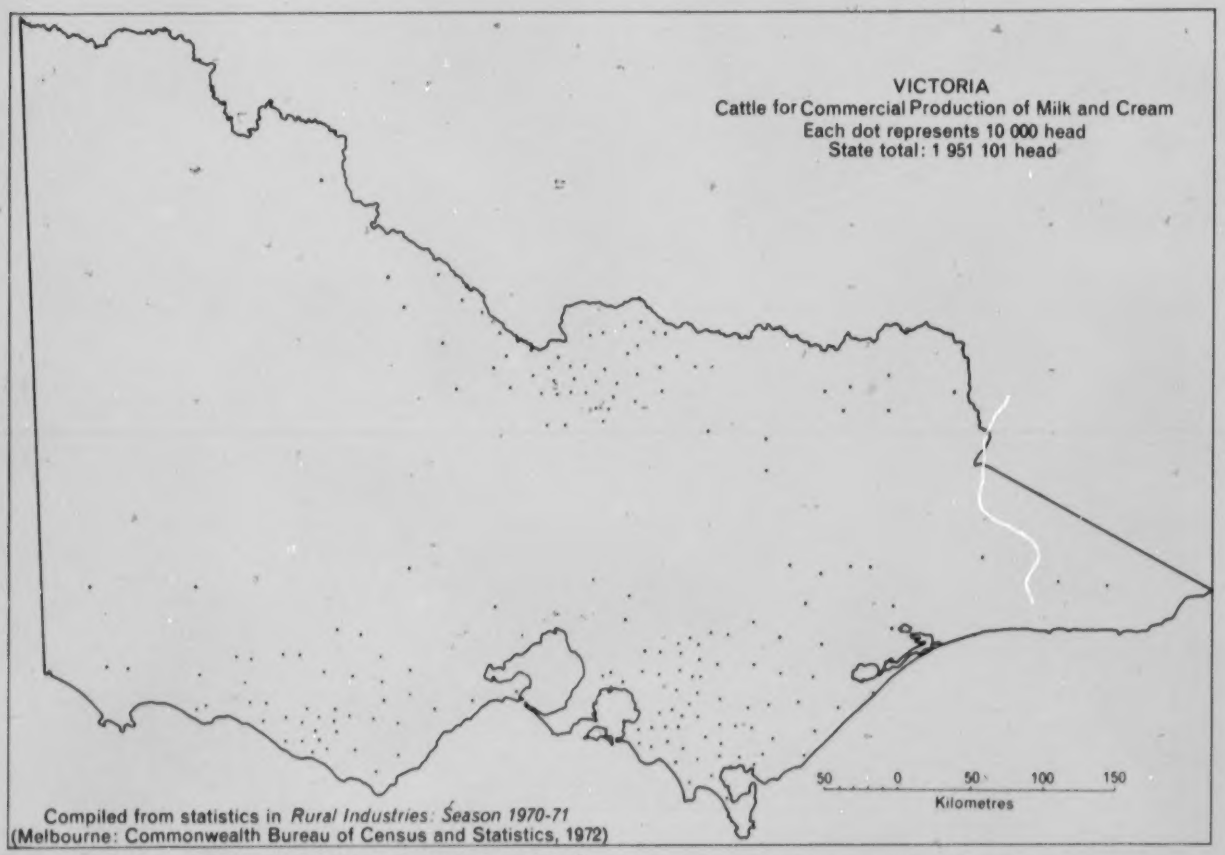

VICTORIA
Cattle for Commercial Production of Milk and Cream
Each dot represents 10 000 head
State total: 1 951 101 head
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.3: Victoria—numbers of cattle for commercial production of milk and cream, 1970–71

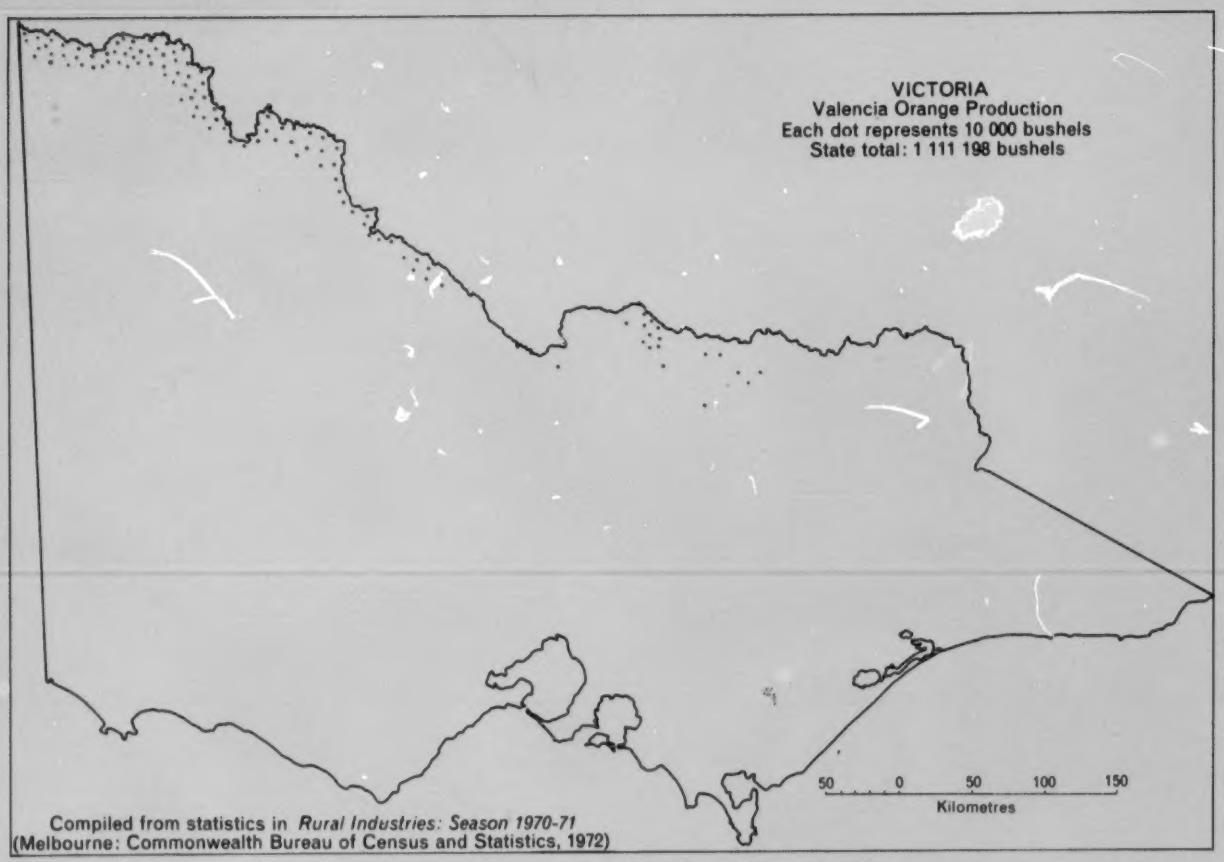

VICTORIA
Valencia Orange Production
Each dot represents 10 000 bushels
State total: 1 111 198 bushels
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.4: Victoria—Valencia orange production, 1970–71

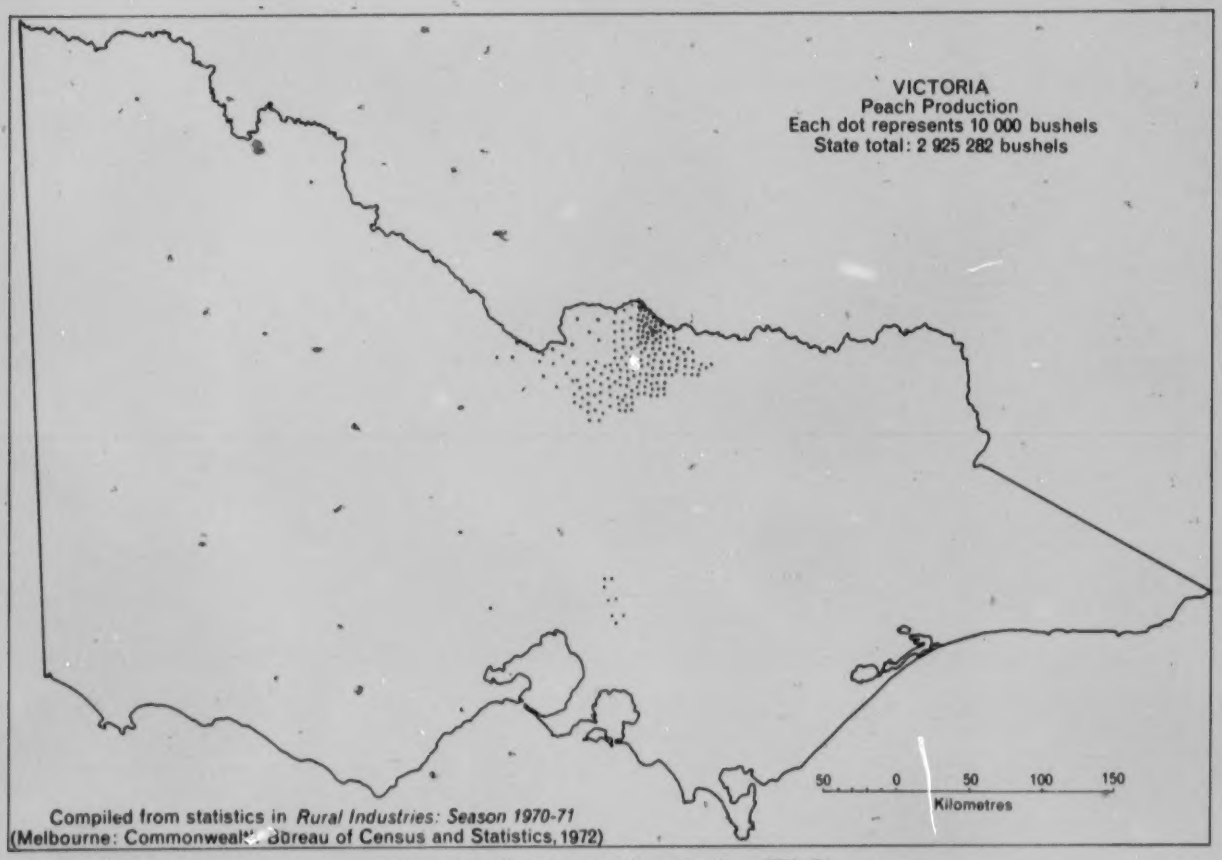

VICTORIA
Peach Production
Each dot represents 10 000 bushels
State total: 2 925 282 bushels
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.5: Victoria—peach production, 1970–71

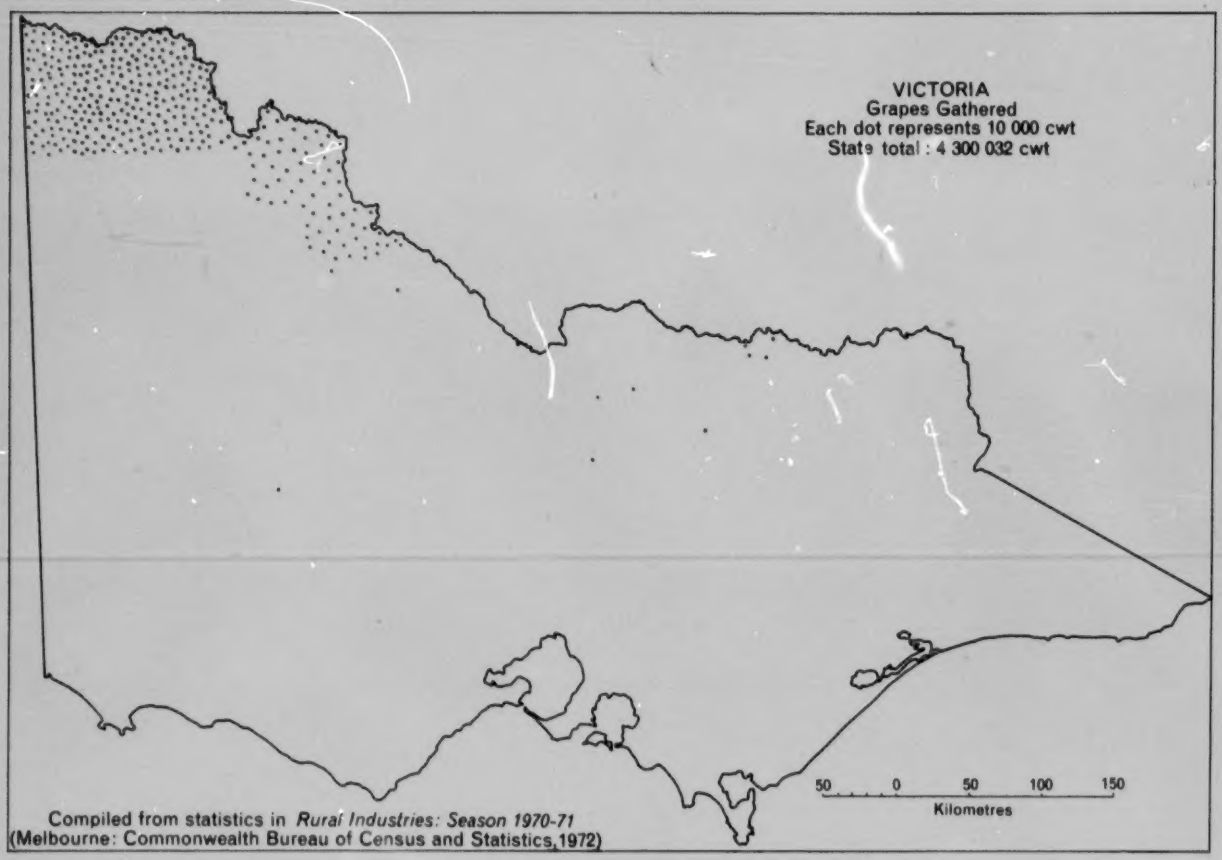

VICTORIA
Grapes Gathered
Each dot represents 10 000 cwt
State total : 4 300 032 cwt
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics,1972)

Figure 2.6: Victoria—total grapes gathered, 1970–71

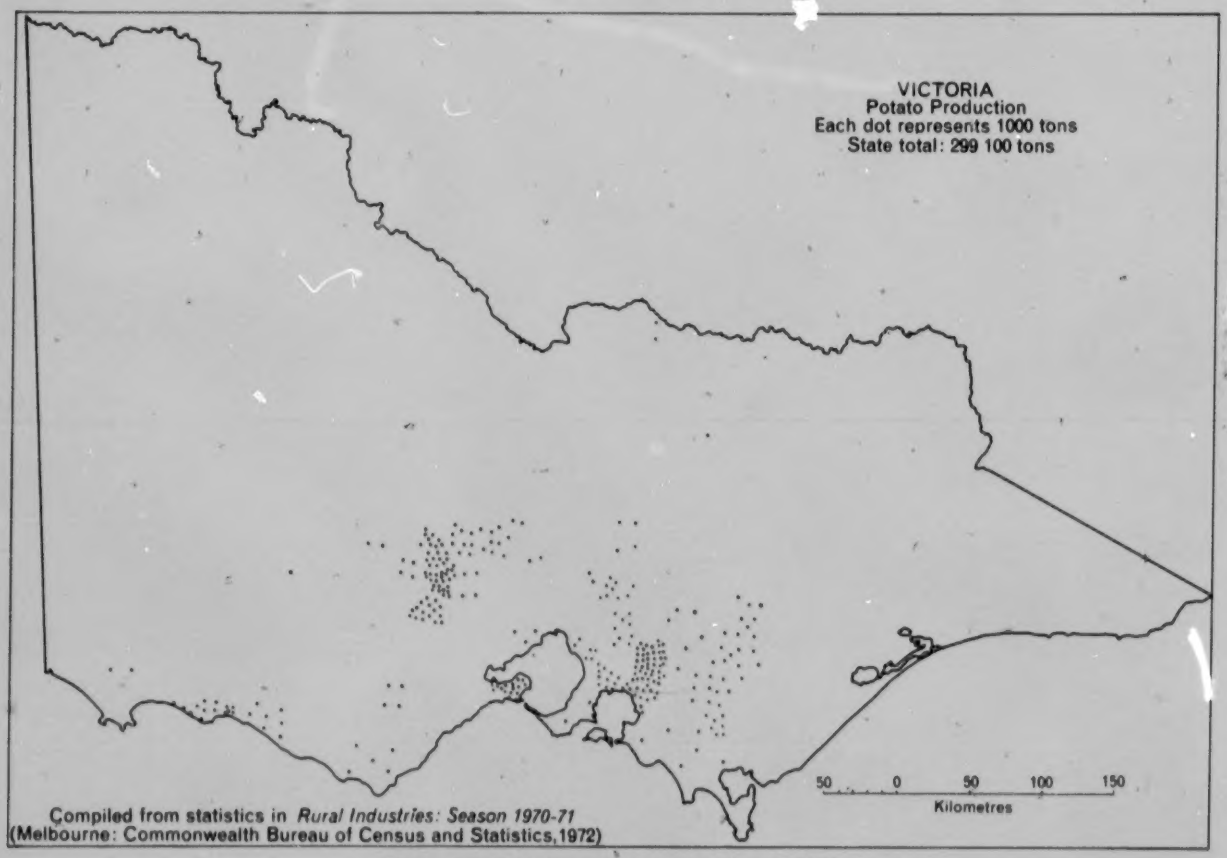

VICTORIA
Potato Production
Each dot represents 1000 tons
State total: 299 100 tons
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics,1972)

Figure 2.7: Victoria—potato production, 1970–71

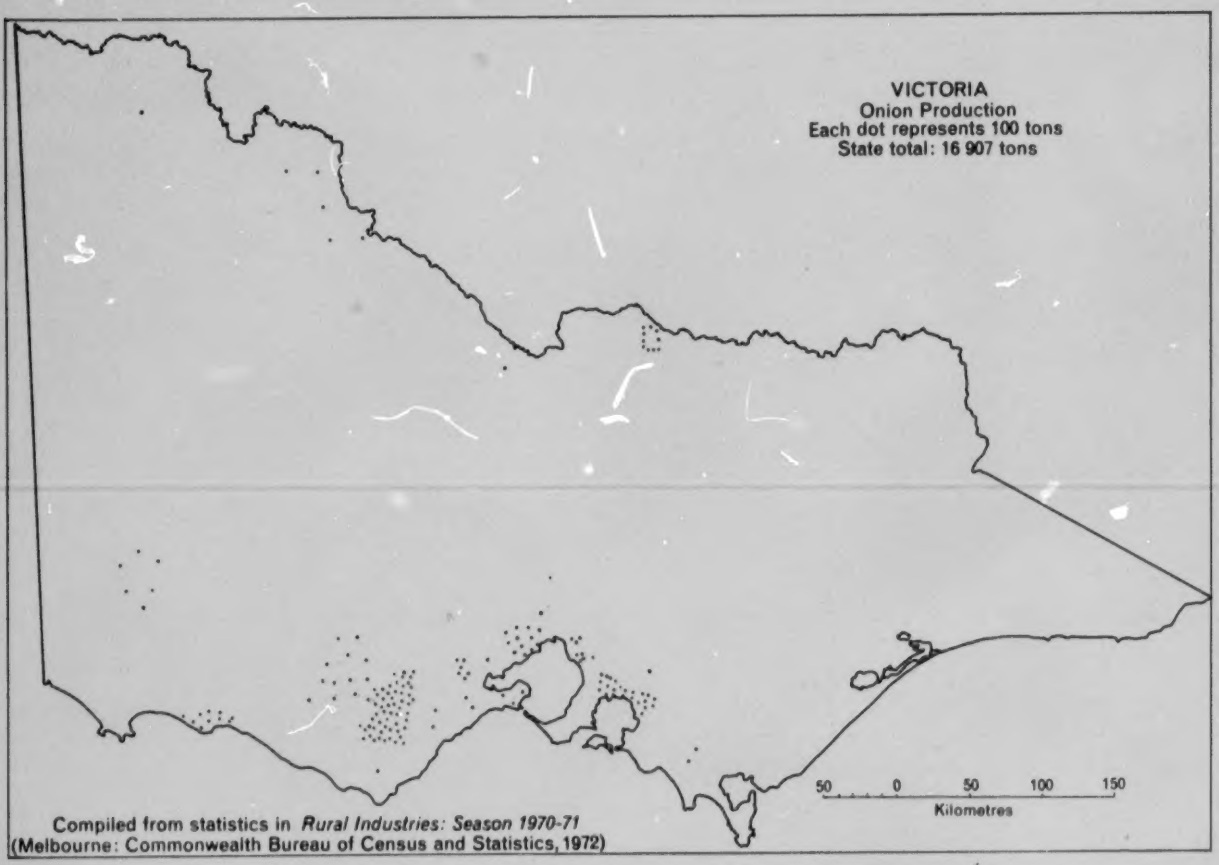

VICTORIA
Onion Production
Each dot represents 100 tons
State total: 16 907 tons
50 0 50 100 150
Kilometres
Compiled from statistics in Rural Industries: Season 1970-71
(Melbourne: Commonwealth Bureau of Census and Statistics, 1972)

Figure 2.8: Victoria—onion production, 1970–71

3

Vegetable production

Vegetable production occurs on farms that are called *market gardens*. Obviously there are differences between market gardens and other farms. First of all, market gardens mainly produce vegetables and others don't—but perhaps there are other more important differences.

In Level One of the Global System series you studied a market garden close to Melbourne. But you only looked at what the farmer did and produced. What else can we consider?

Think about a market garden as a system, with vegetables as the output (what is produced). Most vegetables perish very rapidly once they are harvested and so, because of the constant demand for them, they must be sent to market at regular intervals—at least three times a week. In addition, many vegetables, such as lettuce and silverbeet, are very delicate and will not stand up to long-distance transportation. Refrigeration, which is used during transport of other perishable foods such as meat, is not of much use to market gardeners as most vegetables cannot be frozen. (Have you ever unwittingly put a lettuce in a very cold refrigerator? What happened to it?)

A famous agricultural economist, Johann von Thünen, summed up most of these points as far back as 1826. He stated: 'Delicate horticultural crops such as cauliflower, strawberries, lettuce, etc. would not survive long journeys by wagon. They can, moreover, be sold only in small quantities, while still fresh.'

Thus, as a result of the high and constant demand for vegetables, and because of their perishability and fragility, market gardeners attempt to establish their farms near the market.

Vegetables, by comparison with other crops, are very bulky though not very heavy. This means that while one truck may be able to transport ten tonnes of wheat, it could possibly only carry two tonnes of vegetables. By comparison with most other forms of agriculture, then, the transport costs faced by a market gardener are high. The problem of bulk is compounded by the large number of trips the grower must make to market. And so, in attempting to overcome these high transport costs, the grower will try to establish his farm near the market.

Obviously, urban centres with their high concentrations of population will provide the most attractive market for the farmer. To be able to produce the large volumes of vegetables necessary to justify his use of high-cost land close to the urban market, a market gardener must apply hundreds of tonnes of manure and other fertilisers. Because manure is also bulky and costly to transport, the source of supply has influenced where market gardeners established their farms. In the past, and still to a considerable extent today, growers have been able to buy manure from stables and dairies.

As you saw in Level One, a great deal of skill is involved in successfully growing vegetables. The growers thus develop a close personal interest in their crops, right from the purchase of seed through to marketing. Because of this interest, and because they have to transport the vegetables to market regularly, growers prefer to sell their crop themselves. If their farms were at a considerable distance from the market, this would not be possible; the grower would have to rely on an independent, and often less concerned, marketing representative.

Table 3.1: Vegetable production and gross value per hectare, compared with other forms of farming in Victoria, 1970

Land use	Annual production per hectare	Gross value per hectare ($)
Market gardening	40 tonnes*	4444·00
Dairying, for milk	5860 litres	514·00
Beef cattle	335 kg of beef	212·00
Wheat	1085 kg	89·00
Sheep for wool:		
High rainfall area	18 kg of fleece	15·00
Sheep–wheat zone	4·5 kg of fleece	3·75
Pastoral zone	2·25 kg of fleece	1·88

*1 tonne = 1000 kg
Source: B.A.E. Reports

Refer to table 3.1. What differences do you notice between the production from market gardening and that from other types of farming? What effect would this have on the types of land that market gardeners can buy compared to other farmers?

So far you have read about a number of general factors involved in market gardening; these are all concerned with the *market*. Where is the market for vegetables?

Look at figure 3.1. If cities are important for market gardens, why should the distribution of market gardens around Melbourne be so unusual? What other factors might affect where a market garden is located?

Figure 3.1: Location of market gardens around Melbourne (Source: J. L. Sach, 'The Changing Location of Victorian Vegetable Producers, 1950–69', unpublished honours thesis, Monash University, 1969)

Read through the description of the Dingley market garden in Level One, pages 32–39. What else might be important?

First, in this description the statement is made: 'Heavy irrigation of the crops is necessary for as much as six months of the year. Most farms have dams which they fill from water mains and any run-off from the farm.' This does not explain why the distribution is so scattered—or does it? Is it better to irrigate some areas rather than others?

Second, transport is important (generally road transport), as we have already seen. Look at figure 3.2. Does this map provide evidence that market gardeners locate close to major transport routes?

Third, although the amount of water needed is high, as previously noted, irrigation can have unforeseen effects. Trees and crops will rot if the roots are perpetually wet, and so vegetables need well-drained soils. Also, the amount of handwork required on market gardens suggests that the soils

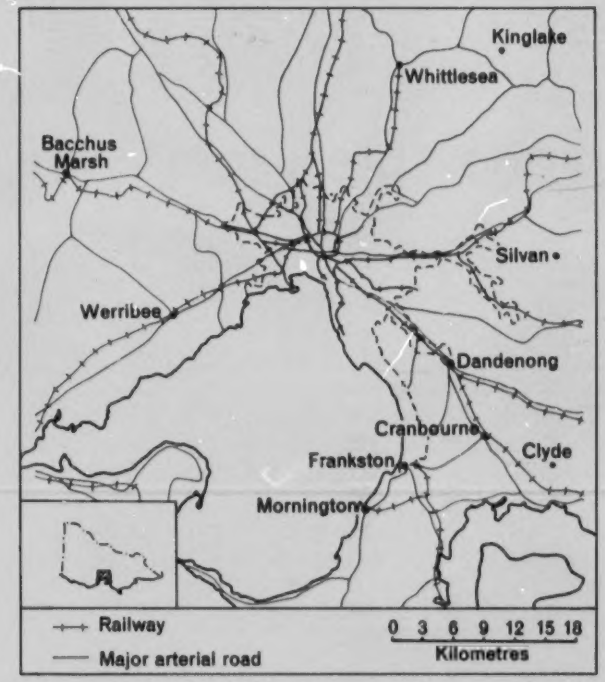


Figure 3.2: Major arterial roads and railways in the area of figure 3.1

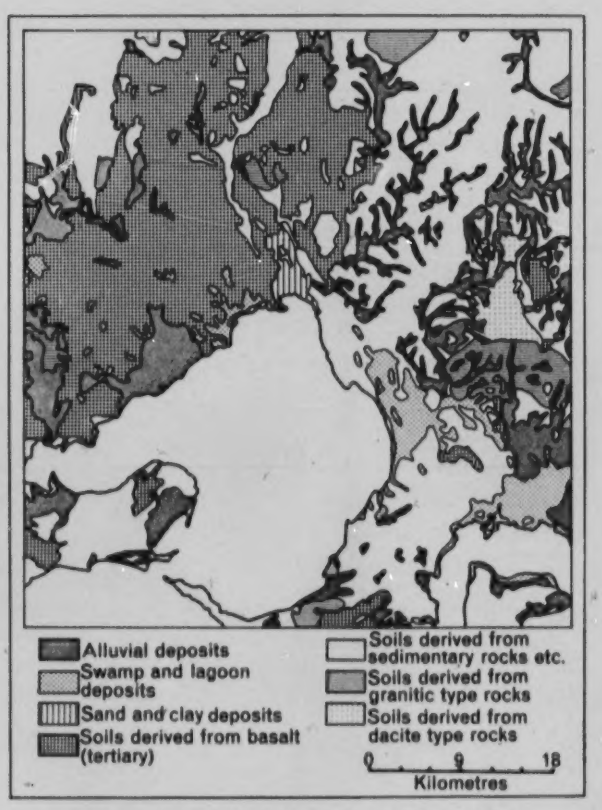

Alluvial deposits
Swamp and lagoon deposits
Sand and clay deposits
Soils derived from basalt (tertiary)
Soils derived from sedimentary rocks etc.
Soils derived from granitic type rocks
Soils derived from dacite type rocks
0 9 18
Kilometres

Figure 3.3: Soil types in the area of figure 3.1

should be easily worked and therefore light and friable. Look at the map in figure 3.3. Which of the soils are those on which the market gardens are found? Are they the easily worked and well-drained soils? Are they fertile? Do they need to be fertile? (See table 4.1 on page 36 of Level One.)

Table 3.2: Use of superphosphate and other artificial fertilisers per hectare

Area	Crop			
	Vegetables	Orchards	Other crops	Pasture
Dingley sample farm area	1750 kg	n.a.	1125 kg	375 kg
Within 50 kilometres of Melbourne	1625 kg	n.a.	1375 kg	250 kg
Within 80 kilometres of Melbourne	1570 kg	750 kg	750 kg	250 kg
The Western District of Victoria	375 kg	375 kg	185 kg	125 kg

Source: Victorian Rural Statistics

Refer to table 3.2. Why is the amount of fertiliser so much higher for vegetables? Why does the amount used for all kinds of agricultural activity decrease to such an extent as the distance from Melbourne becomes greater?

From all this you will have discovered two different ways of explaining why vegetable production occurs where it does. There are a number of general factors and a number of specific factors. But something else is also happening. In Level One, this sentence appeared: 'Some market gardeners may start as many as four new farms in their lifetime' (page 32). Why does this occur?

Earlier we noted that market gardens could be located near cities because they earn more from the land than other types of farming; however, they cannot compete for long against urban expansion and the essential services that gradually intrude. Land values rise rapidly with a consequent increase in the rates that must be paid. As cities grow and expand outwards, so the market gardeners move too, always staying near the urban fringe to gain the advantages of that location.

Thus the market gardener is in an awkward *position; he tries to have his farm* as close as possible to the market (the city), but, as the city grows and the urban functions compete with farms for the land, the farmer has to move farther from the centre of the city.

Characteristics of urban-fringe market gardens

Farm size

Most market gardens near cities are very small. Those south-east of Melbourne average approximately 6 hectares; our Dingley sample farm totals 9·3 hectares. Farther out, farms become larger. Other types of farming not requiring a position near the city are larger still, as table 3.3 shows.

Table 3.3: Farm size comparisons

Farm type and area	Average farm size (hectares)
Market gardens within 30 kilometres of Melbourne	6·0
Other farms within 30 kilometres of Melbourne	16·8
All farms within 80 kilometres of Melbourne	24·3
Gippsland dairy farms	172·4
Wimmera wheat farms	405·5

Sources: Victorian Rural Statistics; B.A.E. Reports

Intensive land use

Market gardeners can only afford to run small farms because of the cost of urban-fringe land and the demand for the land for other uses. As a result, they must use the land intensively to make a living. This is done in two ways:

- by using large amounts of labour, fertilisers and water—the 'inputs';
- by using special farming methods that allow large volumes of vegetables to be produced all year round—the 'outputs'.

So, in producing vegetables, the market gardener has a number of problems, some concerned with the farm itself and others concerned with its location. If market gardeners are forced farther and farther from the centre of their market, will their costs and thus the prices the consumer pays become too high? Can you think of any way of remedying the situation?

4

A deciduous fruit farm in the Goulburn Valley

Fruit growing today is a highly complex business; so that you may understand the many activities involved before the fruit arrives at your table, this study will look in some detail at 'Tranby Croft', Mr and Mrs Spivey's orchard at Shepparton East in the Goulburn Valley (figure 4.1). Mr Spivey's grandparents bought the property in 1912 as an 18·6 hectare closer settlement block, and named it after a family estate in England. They began by setting out 4 hectares for irrigating lucerne, a fodder crop for cattle, and started dairying the following year.

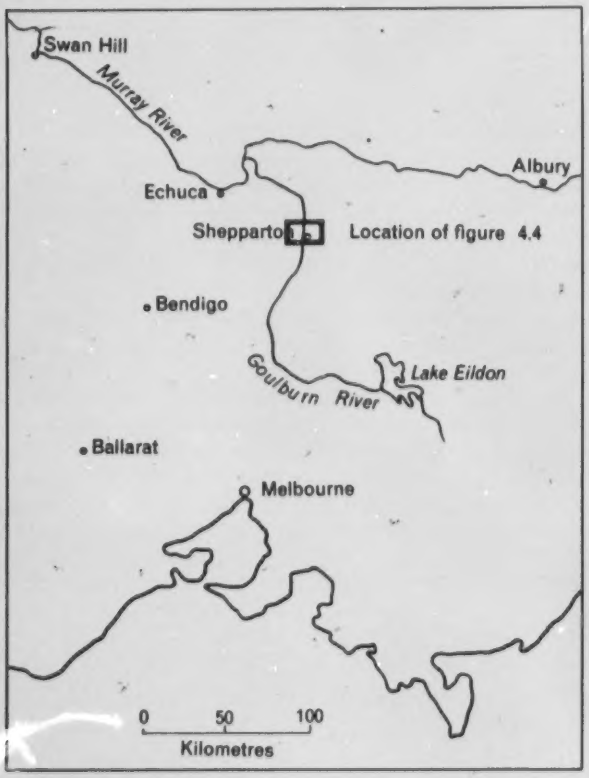


Figure 4.1: Location map

In common with many other dairy farmers in the closer settlement area, however, they found their block too small for economic dairy production. With the 1914–15 drought the problem of feed shortage was accentuated, while at the same time the price for butterfat was declining. As a result, the Spiveys, together with other dairy farmers, decided in 1915 to change over to fruit growing. At least 2 hectares of fruit trees were planted out each year from 1915 until the whole block was finished in 1920. (During the first few years, 4 hectares of oats were also planted each year to provide feed for the horse.)

The fruit trees started to bear after 1918, but full production was not reached until some years later. The stage at which full-scale production is reached varies according to the type of tree, the soils and the management practices, but generally it is ten to twelve years for pears, eight to ten years for apples, and five to seven years for peaches and apricots.

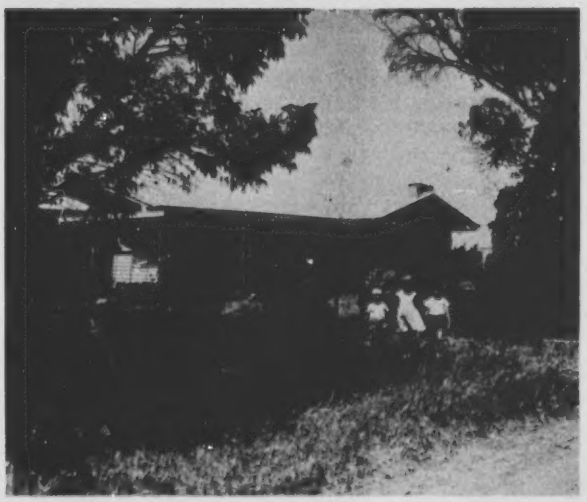


Figure 4.2: Mr and Mrs Spivey's house. From figure 4.3, locate its position in relation to the orchard area. In what direction is the camera facing?

Since these early years, orchard plantings at 'Tranby Croft' have varied considerably as different types and varieties of fruit were tried out. In addition, 1956 was the year of Shepparton's highest annual rainfall; many peach trees throughout the district were killed by excess water and much replanting had to be done.

Figure 4.4 shows the location of the orchard in relation to the city of Shepparton, the main centre of the region, with a population of over 19 000. Although the Spiveys are not far from the city, Mrs Spivey does much of her shopping at the small Shepparton East centre—about one kilometre east of their home along the Benalla Road. At present, their three children, Susan, Ian and Mark (figure 4.2), go to the Shepparton East State School, and to the High School in Shepparton.

How far is the orchard from the Shepparton Post Office? Can you suggest why Mrs Spivey does much of her shopping at the Shepparton East centre? How often does your mother travel to the city to shop?

Fruit growing in the Goulburn Valley

The Goulburn Valley is the largest deciduous fruit growing area in Australia. It is part of the River Plain of south-eastern Australia—a huge plain formed by soil deposition from the Murray and its tributaries over millions of years. The valley is very flat with no distinctive topographical features (figure 4.5). It is crossed by many rivers and creeks, and slopes gently towards the Murray River from an elevation of 120 metres at Murchison in the south, to about 100 metres at Koyuga in the north-west.

The unconsolidated sedimentary deposits (alluvia) form a layer up to 180 metres in thickness over the ancient bedrock. Nearly all this material was deposited by streams no longer in existence (prior streams)—the present streams such as the Goulburn River are not depositing. The valleys of these prior streams eventually filled with material, resulting in the formation of a series of slightly elevated sandy ridges across the plain. It is these ridges of relatively light soils that are used extensively for orcharding in the Goulburn Valley.

In 1967, there were about 1000 orchardists in the valley. All the fruit trees are grown under irrigation on orchards averaging 13 hectares in area. Mostly they are mixed orchards, where at least two but generally three or more different types of fruit are grown. Mr Spivey, for instance, is one of many growers who has planted his block with pears, apricots and several varieties of peaches for canning, together with apples and other varieties of pears for the fresh-fruit market.

About 75 per cent of the fruit trees in the Goulburn Valley produce fruit for canning. The remaining 25 per cent are grown for fresh fruit. This area is the most important production centre for market (fresh) pears in Australia, and, although it produces only a small percentage of the Australian apple crop, it is an important apple exporting area for Victoria.

Relationship between orchard plantings and soil types

The present orchard plantings at 'Tranby Croft' are shown in figure 4.3; they consist of four types of trees (see table 4.1).

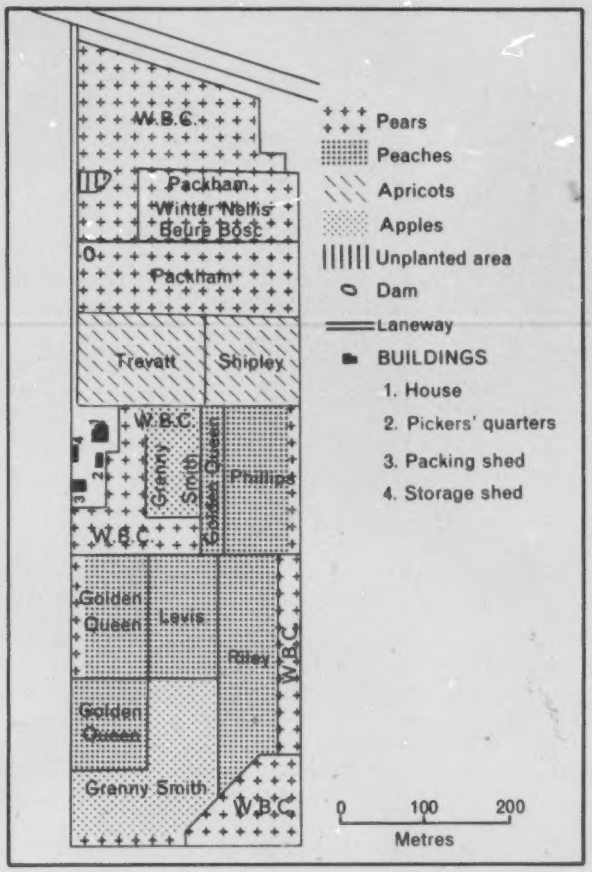


Figure 4.3: Orchard plantings at 'Tranby Croft'

Table 4.1: Orchard plantings at 'Tranby Croft'

Fruit type	Hectares	Number of trees
Pears	7·3	2339
Peaches	6·0	1789
Apples	2·4	682
Apricots	2·0	540

Figure 4.6 is a vertical aerial photograph of the farm and figure 4.3 is a map of the farm. Their scales are different, and they each show different details. Compare the detail on each. Using tracing paper, make your own map of the farm from the vertical aerial photograph, showing the main road, the laneway, the four buildings and the different types of fruit. The photograph was taken in 1964. Indicate on your map the areas that have been planted since then. Calculate the scale of the aerial photograph.

Figure 4.4: Extract from topographic map sheet—Shepparton D, 1:31 680, first edition, 1956 **(Department of Crown Lands and Survey, Vic.)**

MILES 1 ¾ ½ ¼ 0 1 2 3

YARDS 1000 500 1 2 3 4 5000

1 ¼ 0 1 2 3 4 5

KILOMETRES

CONTOUR INTERVAL 25 FEET

		Fenced	Unfenced
Roads	Sealed		
	Gravelled — First class		
	Gravelled — Second class		
	Unsurfaced		
Foot or pack track			
Fence			
Railway — double line			
Railway — single line			
Railway station			
Railway station with siding			
Railway siding			
Bridge			
Telephone or telegraph line			
Electric power transmission line			
Parish (cadastral subdivision of the state)		UNDERA	
Parish boundary (approximate)			
Buildings			
Church		+	
Cemetery		CEM	
Recreation reserve		REC RES	
Windpump			

School	S
Hospital	HOS
Post office	P
Factory or mill	
Quarry	
Levee	
Trigonometrical stations :-	
Fourth order	317 TRIG
River, creek or watercourse	
Aqueduct, channel	A C
Underground pipeline, drain	W D
Water tower	W.T.
Large waterhole or dam	
Swamp	
Contours	250 225 200
Depression contour	400 425
Timber	
Scattered timber	
Orchard	
Vineyard	
Scrub	

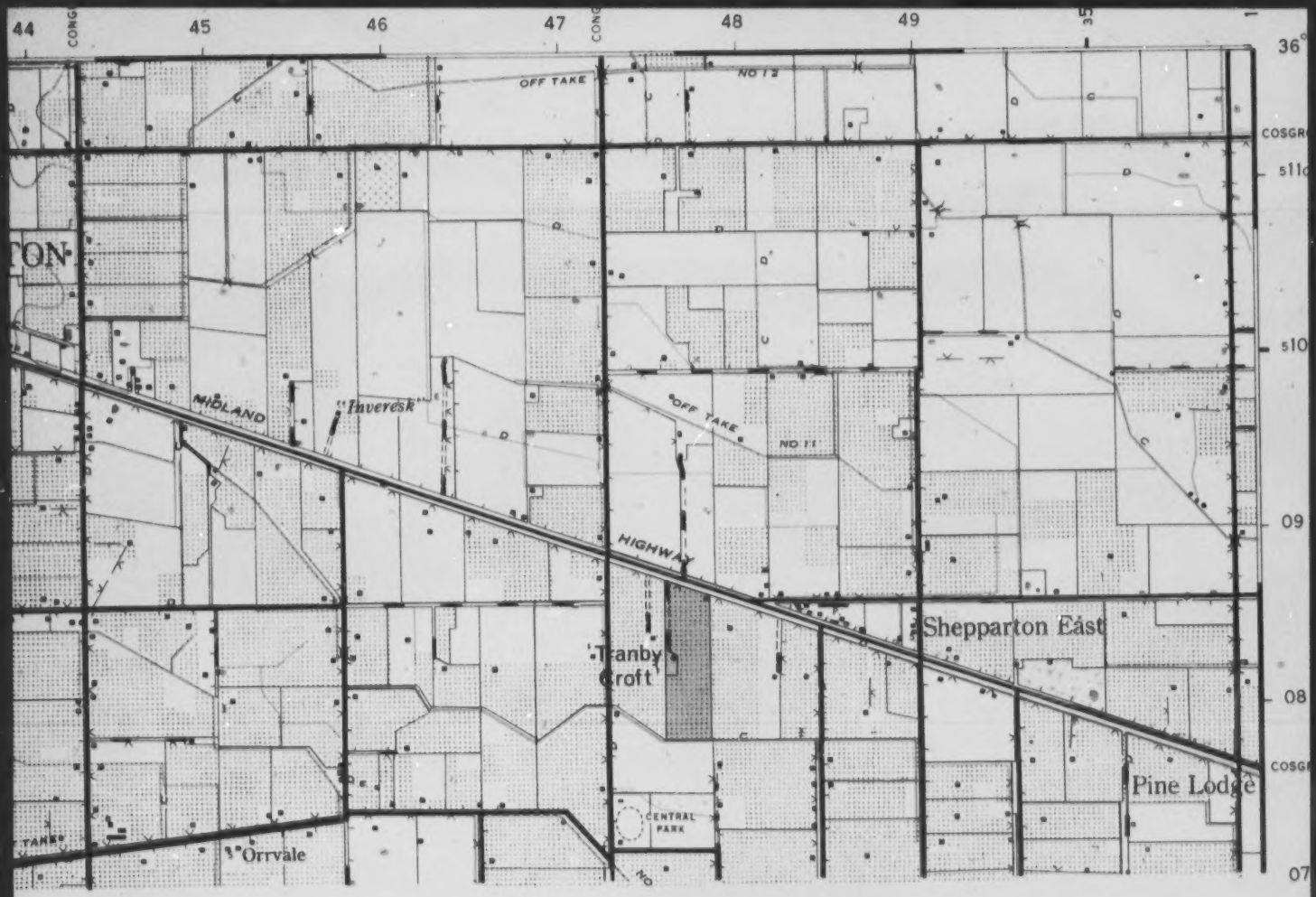


Figure 4.5: The Goulburn Valley plain

27

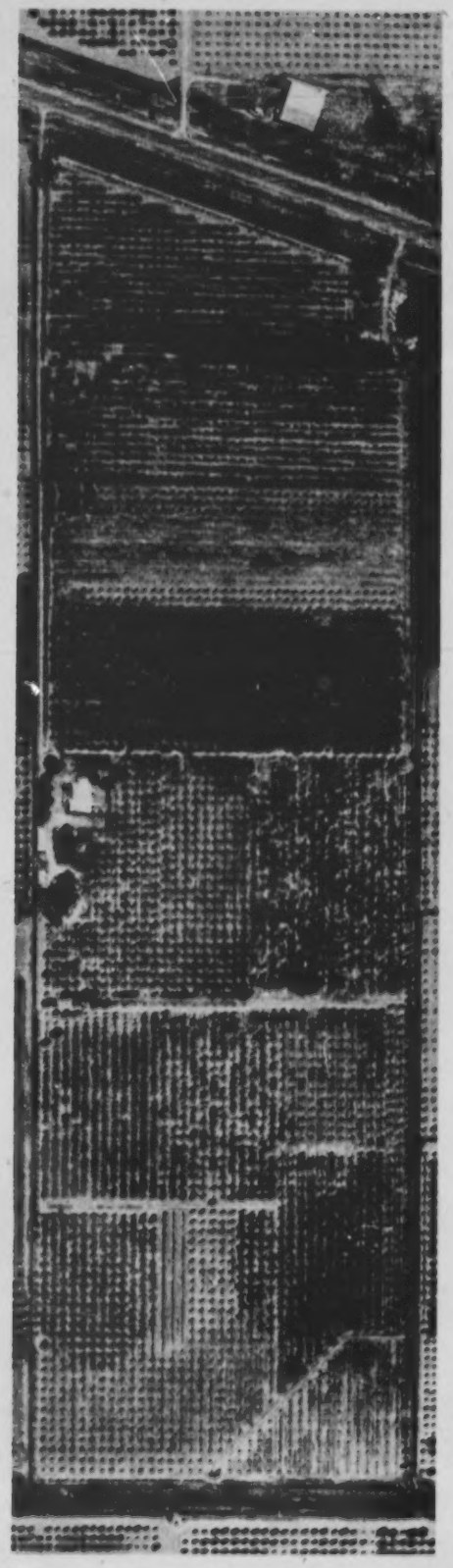


Figure 4.6: Aerial photograph of 'Tranby Croft'

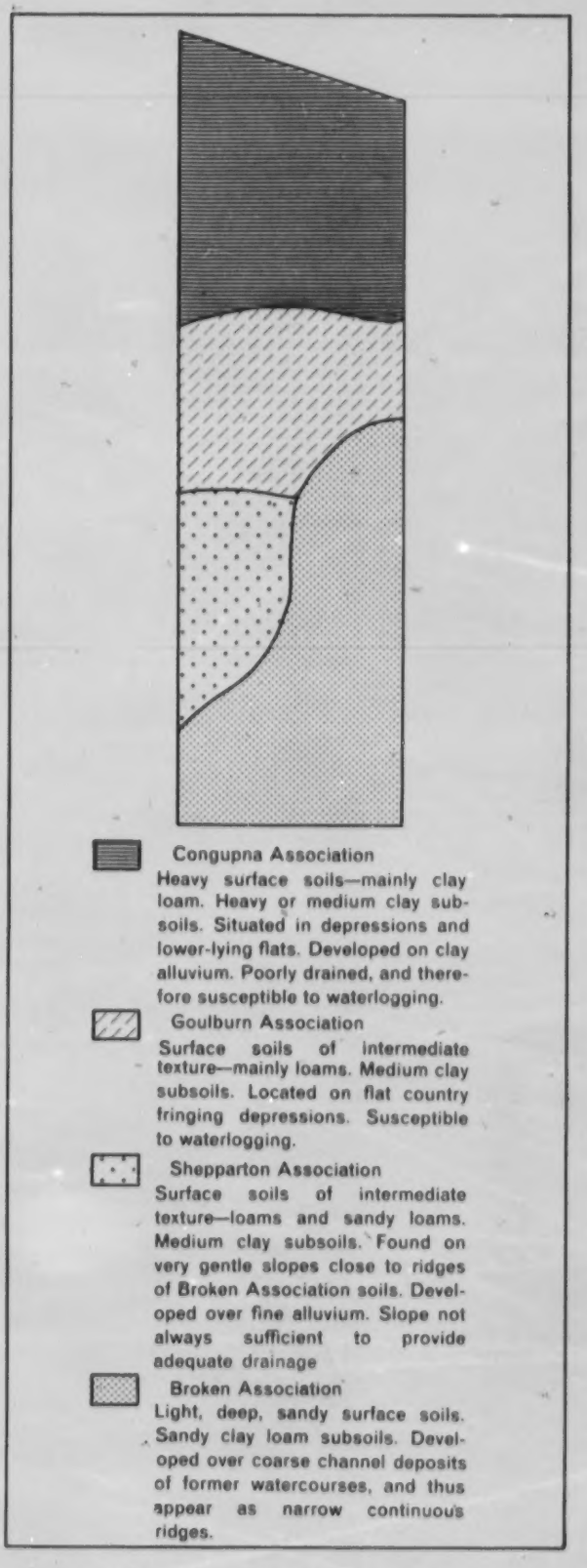

Congupna Association
Heavy surface soils—mainly clay loam. Heavy or medium clay subsoils. Situated in depressions and lower-lying flats. Developed on clay alluvium. Poorly drained, and therefore susceptible to waterlogging.
Goulburn Association
Surface soils of intermediate texture—mainly loams. Medium clay subsoils. Located on flat country fringing depressions. Susceptible to waterlogging.
Shepparton Association
Surface soils of intermediate texture—loams and sandy loams. Medium clay subsoils. Found on very gentle slopes close to ridges of Broken Association soils. Developed over fine alluvium. Slope not always sufficient to provide adequate drainage
Broken Association
Light, deep, sandy surface soils. Sandy clay loam subsoils. Developed over coarse channel deposits of former watercourses, and thus appear as narrow continuous ridges.

Figure 4.7: Soil associations at 'Tranby Croft'

Does the farmer take the soil types into account when he plants his trees? Look at figure 4.7. Can you see any evidence to help you answer this question? Are some types of fruit more suited to better-drained soils?

There is another factor, however, that has some influence on the choice of orchard plantings. While these are determined mainly by soil type, several varieties of trees are usually planted so as to offset any setbacks that might occur with one particular variety (for example, light crop, crop failure, disease, frost or hail damage), and also to provide a sequence of orchard operations to attain the most economic use of the labour available. Relate this statement to apple plantings on 'Tranby Croft'. On what sorts of soils are apples planted? What sort of drainage do apples need?

Rainfall

Average rainfall figures, although giving an indication of conditions to be expected, do not show how the rainfall varies from year to year, or how effective it is. A better indication of rainfall reliability can be obtained by working out the coefficient of variation for a particular place. Table 4.2 shows the actual rainfall for Shepparton over a thirty-year period, 1939–68. The deviation, or difference between the rainfall of each year and the average, is also shown. The coefficient of variation is calculated in the following way:

Total deviation over thirty years = 3871

$$\text{Standard deviation} = \frac{\text{Total deviation}}{\text{Number of years}}$$

$$= \frac{3871}{30} = 129$$

$$\text{Coefficient of variation} = \frac{\text{Standard deviation}}{\text{Average rainfall}}$$

$$= \frac{129}{505} = 0{\cdot}255$$

By way of comparison, the coefficient of variation in Victoria is highest in the Mallee North (0·298), and lowest along the south-west coast (0·117). The higher the coefficient, the less reliable the rainfall.

If you think about it, you will realise that the amount of rainfall any place receives can be looked at in three ways:

- Any place never receives the same amount of rainfall every year. It can vary slightly or markedly from one year to the next.
- Much of the rain that falls evaporates before it can be used.
- Rain may not fall regularly all through the year.

Examine figures 4.8 and 4.9 and table 4.2. What problems would farmers have in this area?

Table 4.2: Shepparton—actual rainfall and deviation, 1939–68

Average rainfall: 505 millimetres

Year	Actual rain (millimetres)	Deviation (millimetres)
1939	894	389
1940	261	244
1941	652	147
1942	552	47
1943	327	178
1944	276	229
1945	416	89
1946	513	8
1947	571	66
1948	489	16
1949	615	110
1950	614	109
1951	572	67
1952	677	172
1953	478	27
1954	644	139
1955	803	298
1956	952	447
1957	388	117
1958	565	60
1959	446	59
1960	557	52
1961	414	91
1962	488	17
1963	629	124
1964	502	3
1965	440	65
1966	650	145
1967	236	269
1968	592	87

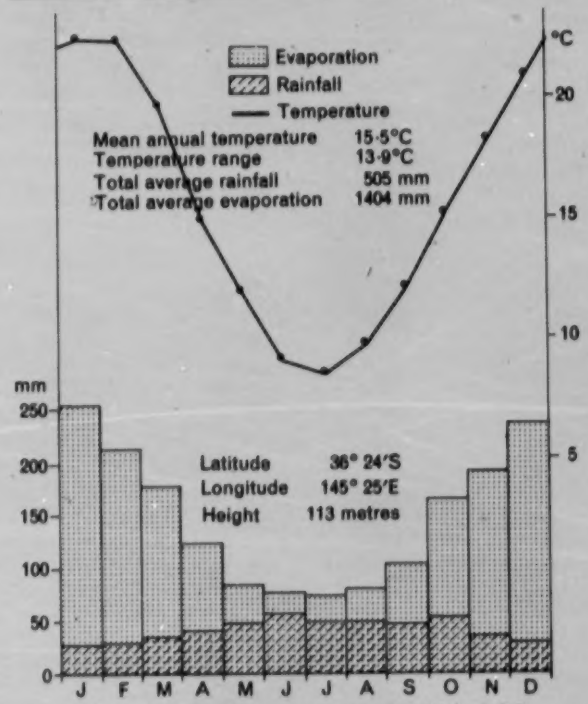


Figure 4.8: Shepparton—average monthly rainfall, temperature and evaporation

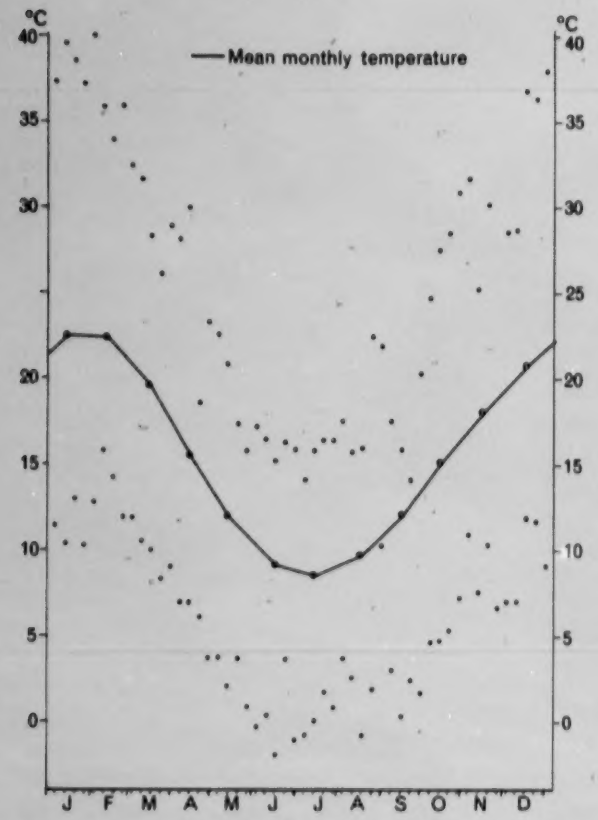


Figure 4.9: Scatter diagram of mean monthly temperatures and absolute weekly extremes, Shepparton, 1969

Mr Spivey has one other worry as a fruit farmer —frost. Very cold air can kill or damage fruit trees. Examine figure 4.9. In how many weeks of the year would Mr Spivey have a problem due to cold temperatures?

So Mr Spivey has at least two problems in running his farm.

Table 4.3: Scoresby—average monthly rainfall, evaporation and temperature

	Rainfall (millimetres)	Evaporation (millimetres)	Temperature (° Celsius)
Jan.	40·1	159·8	19·1
Feb.	66·3	122·2	18·5
Mar.	52·1	106·9	17·2
Apr.	82·6	73·4	14·0
May	104·9	43·4	11·2
Jun.	70·4	33·8	9·0
Jul.	83·6	33·3	8·7
Aug.	83·1	45·5	9·6
Sep.	98·3	61·7	11·6
Oct.	108·5	82·0	13·3
Nov.	98·6	102·4	14·6
Dec.	73·4	132·1	17·2
Year	961·9	996·5	13·7

The figures in table 4.3 show the average monthly rainfall, evaporation and temperature for Scoresby, a small fruit-growing area 29 kilometres east of Melbourne. Orchards in this area grow mainly apples, but also peaches and pears.

Using the same scale as in figure 4.8, graph these figures. Explain, on a climatic basis, why it appears that Goulburn Valley orchardists

(a) grow mainly peaches and pears with fewer apples, whereas Scoresby orchardists grow mainly apples;

(b) need irrigation during the summer months, while growers at Scoresby use only supplementary irrigation or none at all.

Overcoming the water problem

If Mr Spivey doesn't receive enough rainfall for his farming requirements and if he isn't sure about the amount of rainfall that he will get, what can he do? The State Rivers and Water Supply Commission (S.R.W.S.C.) provides water through an irrigation system. It is decided that a certain area needs a larger and more reliable water supply than is provided through rainfall; a major river is dammed to store the water and then channels carry the water to the farms. (Refer to study 25.)

Figure 4.10: A Dethridge meter wheel, used to measure water supplied to irrigation farms from the Water Commission's main supply channels

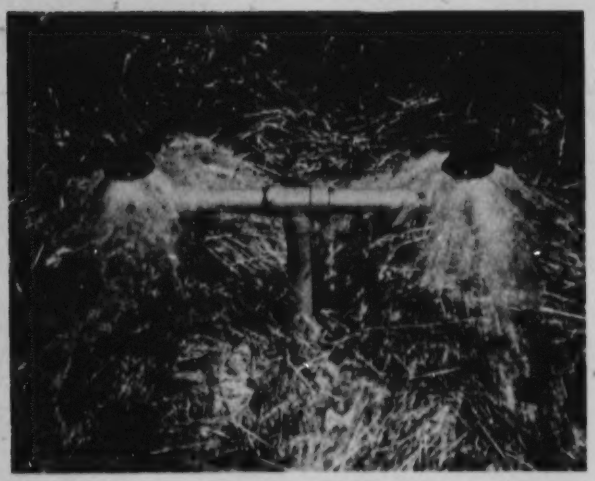


Figure 4.11: Pipe and riser outlet from an underground irrigation pipeline. Why has straw been placed around the outlet?

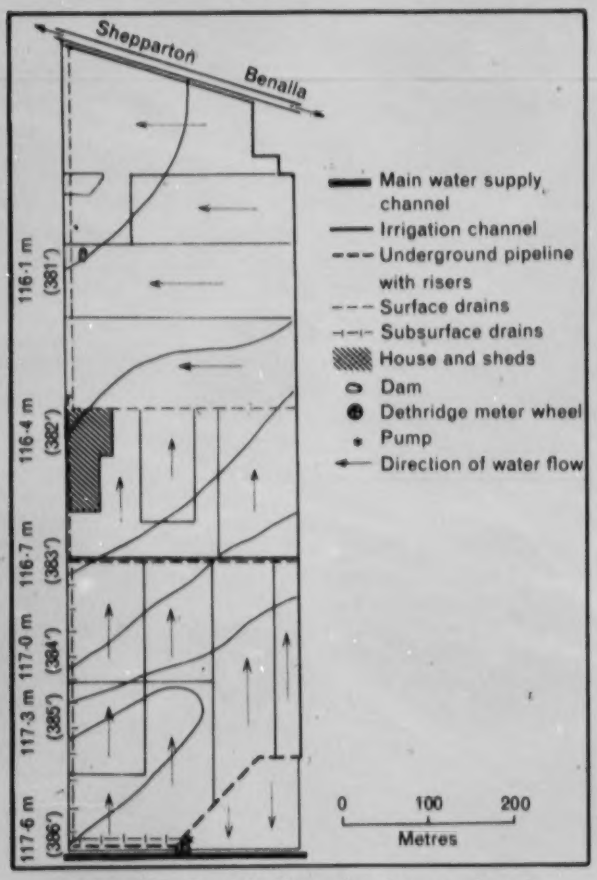


Figure 4.12: The irrigation and drainage system at 'Tranby Croft'

Up to the 1967–68 season, water was supplied to the whole 'Tranby Croft' orchard via open earthen channels, as shown in figure 4.10. Since then, Mr Spivey has installed an underground pipeline and riser system (figure 4.11) to supply part of the block. Figure 4.12 shows the irrigation and drainage layout at 'Tranby Croft'. Which parts of the farm have the underground system and which do not?

Mr Spivey decided to replace the open channel system in this part of the orchard to overcome the difficulties associated with forming and maintaining open earthen channels in the sandy loam soil. The underground system would eliminate channel maintenance work; speed up orchard operations; lessen damage to tractors and implements; ensure better control over water; and save labour—for example, by avoiding the construction of channels at the beginning of each irrigation season, and the continual opening and shutting of outlets in the channel bank.

Mr Spivey has installed a pump at the meter wheel outlet (figure 4.12) to provide the pressure needed for the pipe and riser system. Although the whole orchard is 'commanded' by the main supply channel, and can therefore be watered entirely by gravity, he uses this pump to water the rest of the orchard more quickly—it now requires only three days instead of five.

Figure 4.13: Flood irrigation—the most common method of irrigation in Victoria

Mr Spivey flood-irrigates his whole orchard; that is, the irrigation water covers all the land surface between the rows of trees (figure 4.13). On most orchards, both flood and furrow irrigation methods (figure 4.14) are used, depending on the soil type, the slope, and the length of irrigation bays. Flood irrigation is best on the heavier, less permeable soils, but, on lighter soils with high permeability, furrows can thoroughly wet the soil, while at the same time giving much better control over the water applied. Some orchardists also use spray irrigation (figure 4.15).

Figure 4.14: Furrow irrigation—this method is widely used for watering fruit trees, vegetables and vines. Water is supplied to individual furrows from a head ditch, from a pipeline with risers, or in this case from a flexible plastic pipe

Figure 4.15: Spray irrigation—water is pumped through reticulating pipelines or hoses under pressure and applied to the trees or crops by spray heads. Spray systems can be movable as on this orchard, or fixed in position

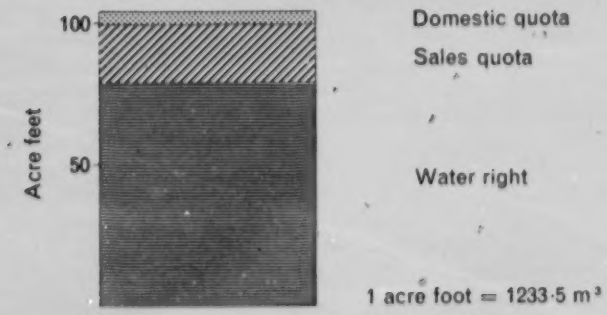


Figure 4.16: Water allocation for 'Tranby Croft'

A total of 127 420 cubic metres (103·3 acre feet) of water has been allocated by the Water Commission to the orchard for both irrigation and domestic purposes, as shown in figure 4.16. During the irrigation season, extending from September to March, the fruit trees are watered every ten to twenty days, depending on the daily evaporation rate and the rainfall. Irrigation is not just a haphazard application of water to the soil; the fruitgrower needs to know the moisture requirements of the trees so that he can apply the right amount of water at the right time. Two methods are used to decide on the best time to irrigate:

- A soil auger is used to take samples from various parts of the orchard for assessment of the moisture content.
- An evaporimeter is used to measure the rate of evaporation. (Refer back to figure 4.8.)

Good drainage essential

Fruit trees must have good drainage to flourish. If water is allowed to lie around the tree roots for long periods it can kill them. The symptoms of waterlogging in the root zone are characteristic—the foliage is sparse, light in colour and small, and the tree lacks its normal vigour.

On the heavier soils, with less permeable clay subsoils, excessive water results in surface waterlogging—the surface soil remains saturated and the tree roots in it are killed. On the lighter soils, which are permeable to a greater depth, a water table can develop under irrigated conditions, and its rise will also kill the trees. Surface waterlogging is controlled by careful grading of the ground surface to ensure maximum run-off of excess water. Water tables are controlled by underground pipe drains placed at depths of one to two metres.

Figure 4.12 shows that Mr Spivey uses both surface and subsurface drains to remove surplus water that may accumulate after heavy rains or irrigation. Two methods of surface drainage are shown in figure 4.17. In (a), a wide graded furrow is located centrally between the rows of trees, and in (b) two smaller graded furrows are placed on either side of each tree line. In addition, Mr Spivey has recently installed a subsurface system of slotted plastic drainage pipes to aid in lowering the water table.

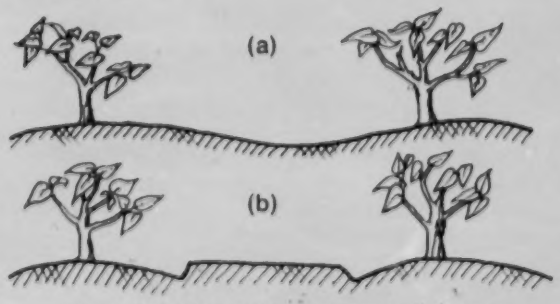


Figure 4.17: Two methods of surface drainage

Work on the orchard

Mr Spivey is busy all the year, his main tasks being pruning, spraying, applying fertilisers, preparing for irrigation, frost protection and fruit picking.

Pruning

The main job to be done during the winter months is pruning (figure 4.18). This is necessary to regulate the amount and size of the fruit produced. The trees must also be shaped correctly to allow sunlight to penetrate evenly, to permit easy access along the rows by tractor, to ensure an even coverage of chemical sprays and to get rid of old, unproductive or diseased wood.

Figure 4.18: Pruning on 'Trahby Croft' using a steel tripod ladder. Most of the pruning is done by the permanent employee, although one or two extra men are taken on for a short time. Each man prunes about twenty-five trees per day, depending on tree size. Table 4.1 shows the number of trees in the orchard—approximately how long would it take one man to prune them all?

Spraying

Chemical sprays are essential for controlling the numerous diseases and pests that attack the fruit trees. Some of the diseases are brown rot, blossom blight, and black spot; the pests include San José scale, aphis, mites, oriental peach moth, mealy bug and codling moth. To keep such a large number of pests and diseases under control, a variety of chemical sprays are used throughout the whole growing season from August to March. The chemicals are applied to the trees, between irrigations, with an air-blast sprayer, which is pulled along the rows behind a tractor (figure 4.19).

Figure 4.19: Air-blast sprayer

The use of sprays, however, can severely affect the bee population. As bees are important for cross-pollination, steps should be taken by the fruitgrower to protect them from toxic sprays. To lessen the damage to bees, the Department of Agriculture recommends that sprays should not be used during the bloom period, and that they be applied at times of low bee activity, such as at night or in the early morning.

Figure 4.20: Spreading fertiliser

Applying fertilisers

During spring, Mr Spivey prepares the orchard for irrigation, applies fertilisers (figure 4.20), and sprays. All fruit trees are given different mixtures and quantities of superphosphate, nitrogenous and, in some cases, potash fertilisers—making for healthier trees and better fruit production. In some parts of the Shepparton area, trace elements are also applied to rectify zinc or magnesium deficiencies in the lighter soils.

Preparing for irrigation

The extent of preparation for irrigation varies considerably, both among different orchards and within a particular orchard, depending on the nature of the ground between the rows of trees. Techniques include:

- *Clean cultivation.* The ground is kept completely free of all grass and weed growth by cultivating the soil and using weedicides (figure 4.21). Fruit trees, especially peaches, are sensitive to competition during the growing season.

Figure 4.21: Clean cultivation of the ground

- *Cover crops and natural grass growth.* In some orchards, crops such as oats are sown, but more commonly natural grasses and clovers are encouraged to grow during the winter months. This improves the soil structure, so that the soil will be easier to irrigate and will hold moisture better during the hotter months. During the irrigation season, the grasses are ploughed in and the ground regraded up to three or four times. Instead of cultivating each time, grass growth can be kept down by slashing and by the use of weedicides along the tree line.

Figure 4.22: Permanent sward cover of clover and grasses

- *Permanent sward.* The ground has a permanent cover of white clover and volunteer grasses, thus eliminating the need for cultivation (figure 4.22). The grass is cut regularly, about every three weeks in summer. Very careful preparation of the ground is necessary before sowing the clover, to ensure efficient irrigation and good drainage. Because of the grass cover, one or two additional irrigations are usually needed during the season.

At 'Tranby Croft', Mr Spivey has a combination of oats and natural grasses throughout most of the orchard, but he also has a small section of permanent sward—the area under Golden Queen peaches and Granny Smith apples in the south-western part of the block (figure 4.3).

There is now a trend towards fewer cultivations in orchards, and some growers are changing over completely, establishing a permanent sward. This is because permanent sward is a more convenient and cheaper soil management system. However, because the ground cover competes with trees for water and nutrients, the number of growers who have made the change is limited, especially in the case of peach growers.

Much time is spent in getting the 'Tranby Croft' orchard ready for the irrigation season. The oats and grasses have to be ploughed in, the drainage furrows levelled out, and the ground carefully graded to ensure an even flow of irrigation water down the rows. In addition, the permanent channels must be cleaned out, and other channels and drains formed where necessary. The irrigation season is from September to March, but the actual start of the first irrigation depends on the spring rains. (Refer back to figure 4.12 to refresh your memory on Mr Spivey's system of irrigation.)

Frost protection

During October and November, Mr Spivey must watch the daily weather conditions very carefully, as this is the time of year when frost damage to the fruit is most likely.

Most frosts occurring in the Goulburn Valley area are the result of radiation, and much can be done to reduce their severity if the fruitgrower is properly prepared. Usually, frosts occur under anticyclonic conditions, when clear skies favour radiation of heat from the ground, and the absence of wind allows the air near the ground to be chilled to freezing temperatures.

Several factors influence the amount of frost damage that may be done to fruit trees. Soil conditions are very important in frost control, for the risk of damage is lessened according to the ability of the soil to store the heat received from the sun, and to conduct this stored heat to the surface at night. A loose, dry soil surface is poor at storing and conducting heat, and for maximum frost protection it is necessary to moisten and compact this

soil. This increases the amount of heat reaching the surface from within the soil: the more heat the soil can supply, the smaller will be the fall in air temperature.

Other factors affecting frost damage include the length of time low temperatures persist, the weather preceding the frost, the rate at which the temperature falls, and the vigour of the tree. Damage to vegetation by frost is not due to the formation of frost itself, but results from the effect of low temperatures on the water in the plant cells.

As both apricot blossom and small green apricots are particularly susceptible, Mr Spivey has concentrated his frost protection efforts in this part of the orchard. (Refer back to figure 4.3 for the location of the apricot block.) Here he has installed a series of 'frost pots' or oil burners, and an alarm system based on temperature in the orchard. Two thermometers are used: one inside the apricot block, the other outside it. Once the temperature goes down to 0°C in the apricot block, an alarm is set off in the house. The stage of fruit growth then determines whether or not the burners are lit (figure 4.23).

Figure 4.23: A 'frost pot'

Figure 4.24: Fruit picking—pears are emptied from the picker's canvas bag into one of the half-tonne bulk bins on the trailer. Refer to figures 4.25 and 4.26

Fruit picking

Fruit picking is a very busy time for the Spivey family (figure 4.24). Picking begins in December with the apricots, followed by pears from mid-January to mid-February, peaches in February and March, and apples in March and April. Mr Spivey employs two or three seasonal workers—usually canecutters from Queensland, who come to the Goulburn Valley after cane cutting is finished. The pickers are provided with living quarters on the orchard.

During the harvesting season in the Shepparton district, there is a huge influx of people seeking work as pickers. Most of them come from Queensland and migrant hostels, but they also include students.

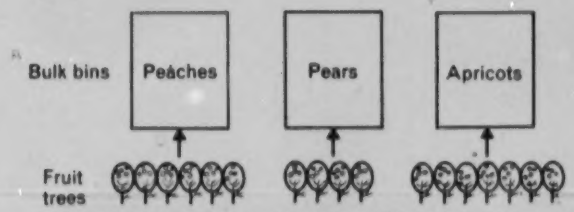


Figure 4.25: Fruit trees required to fill each bulk bin

The average number of fruit trees needed to fill one of the half-tonne capacity bulk bins shown in figure 4.24 is indicated diagrammatically in figure 4.25. The flow chart in figure 4.26 shows the main activities involved in getting the fruit from the tree to the cannery. Once picked, the canning fruit is graded on the orchard as soon as possible (figure 4.27), and taken to the cannery daily (figure 4.28). This is especially important for apricots and peaches. Mr Spivey uses the Shepparton Preserving Company (S.P.C.) cannery. There are two other canneries in the Goulburn Valley: the Kyabram Preserving Co. at Kyabram, and the Ardmona Fruit Products Co. at Mooroopna. (See study 18.)

Not all of Mr Spivey's fruit goes to the cannery, however. The apples and some varieties of pears are sold as fresh fruit; once picked, he sends these straight to one of the packing companies in the district, where they are graded and packed for both export and local markets.

Figure 4.29 summarises this orchard work in a farmer's calendar.

1. Which activities are concerned with caring for the fruit trees?
2. Which figures illustrate these activities?
3. In what months are these activities carried out?
4. Using figure 4.8, describe the weather conditions that could be expected while carrying out these activities.
5. Which activities are concerned with preparing the ground?
6. In what months are these activities carried out?
7. Using figure 4.8, describe the weather conditions that could be expected while carrying out these activities.

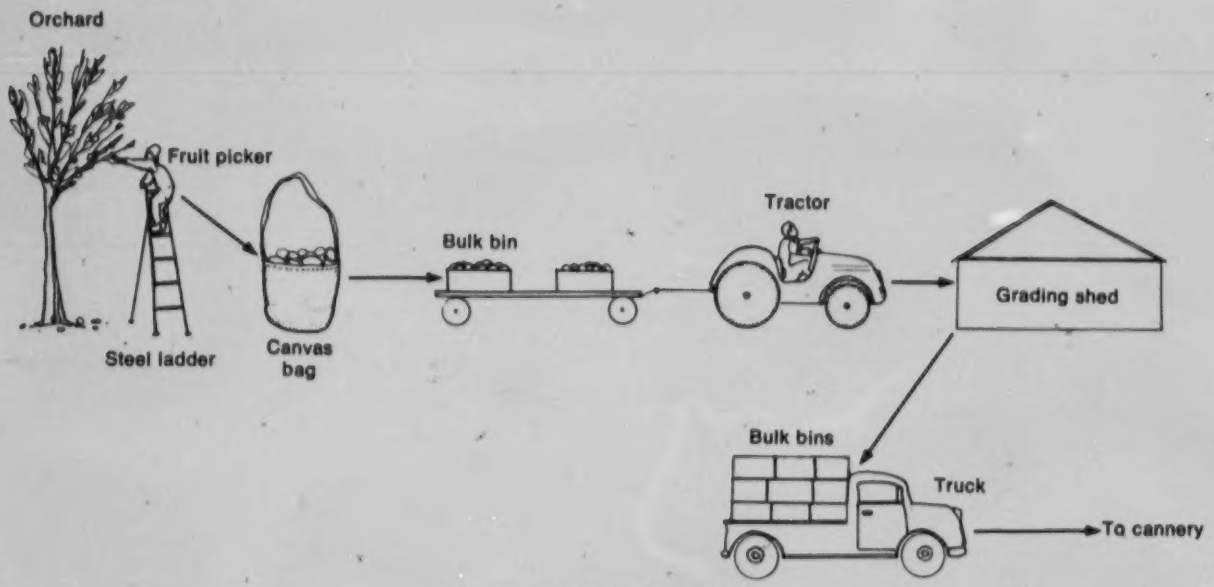


Figure 4.26: Harvest flow chart

Figure 4.27: Grading fruit—the bulk bin at the rear of the shed tips pears on to the moving belt of the automatic grader. The three metal sizing rings on the grading bench in the foreground are used to make sure no over- or under-sized fruit is sent to the cannery

Figure 4.28: Loading bins of graded fruit on to the truck by forklift, ready for transporting to the cannery

Figure 4.29: Farming calendar for 'Tranby Croft'

8. Refer to figures 4.25, 4.26 and 4.29. What activities are concerned with harvesting?
9. Which figures illustrate these activities?
10. In what months are these activities carried out?
11. Using figure 4.8, describe the weather conditions that could be expected at this time of year.
12. Draw a table as at the end of this paragraph. List the fruits in the first column, and mark with a cross the months in which each individual type of fruit is harvested. Which is the heaviest harvesting month? What is the busiest time of year for Mr Spivey? When would be the best time for holidays?

Harvesting

Fruits	D	J	F	M	A	M	J	J	A	S	O	N

Assistance to fruitgrowers

In all aspects of orchard and irrigation management, fruitgrowers in the Goulburn Valley are able to obtain advice and assistance from field officers of the State Rivers and Water Supply Commission and the Department of Agriculture.

An important activity currently being undertaken by the Irrigation Research Section of the Water Commission is the design and supervision of installation of subsurface pipe drains. Such drainage has been a standard item in most horticultural areas in Victoria for many years, but was previously thought unnecessary in the Goulburn Valley. However, high losses of peach trees due to waterlogging in the past ten years have convinced many orchardists that subsurface drainage is equally as necessary as surface drainage.

Pumping water from the shallow sand beds that underlie many orchards is also being studied by the Water Commission as a means of reducing waterlogging in the Goulburn Valley. In some cases, this may prove an economical alternative to subsurface pipe drainage. In others, it may even be necessary to have both systems of water table control.

The Department of Agriculture is assisting Goulburn Valley orchardists in two ways—first, through their Extension Service in which field officers, especially orchard supervisors, are in day-to-day contact with the growers, and second, through their Horticultural Research Station at Tatura. This is the largest of its kind in Australia. The station covers an area of 42 hectares, of which 23 hectares are planted, and carries out research work both in the laboratory and in the field. The most important horticultural problems investigated are involved with soils, irrigation, drainage, plant nutrition, crop control, insect pests and plant diseases.

Figures 4.30 and 4.31 show the layout of the research station. Study these carefully and trace your own map from the aerial photograph, showing the research laboratories and administrative block; the packing shed; the residence of the officer in charge; the tree nursery; the weather station; and the areas where soil management, pruning, rootstock, drainage and irrigation trials are carried out.

Both the research station and the extension officers provide fruitgrowers with technical advisory services, including land use surveys, orchard design, irrigation management, drainage and nutrition advice. Such assistance has been of tremendous value to many orchardists. Mr Spivey, for example, obtained information on subsurface drainage and the value of permanent sward before going ahead with these innovations on his own orchard.

Although the Goulburn Valley is, perhaps, best known for its canning fruit, there are many other types of irrigation farms. If you were to drive through the area today you would find that the greatest concentration of orchards is to the east of Shepparton, between the town and the East Goulburn Main Channel. Elsewhere, the orchards are more scattered and are interspersed mainly with dairy farms (figure 4.32), but also with farms raising fat lambs and beef cattle, or growing tomatoes and other vegetables (figure 4.33).

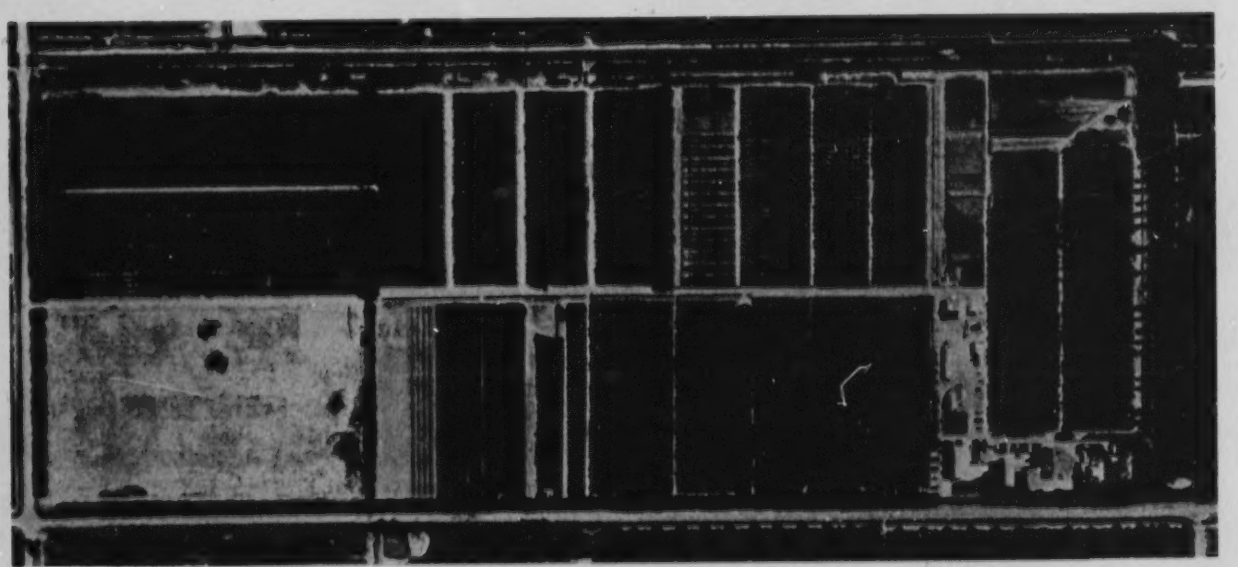


Figure 4.30: Tatura Horticultural Research Station

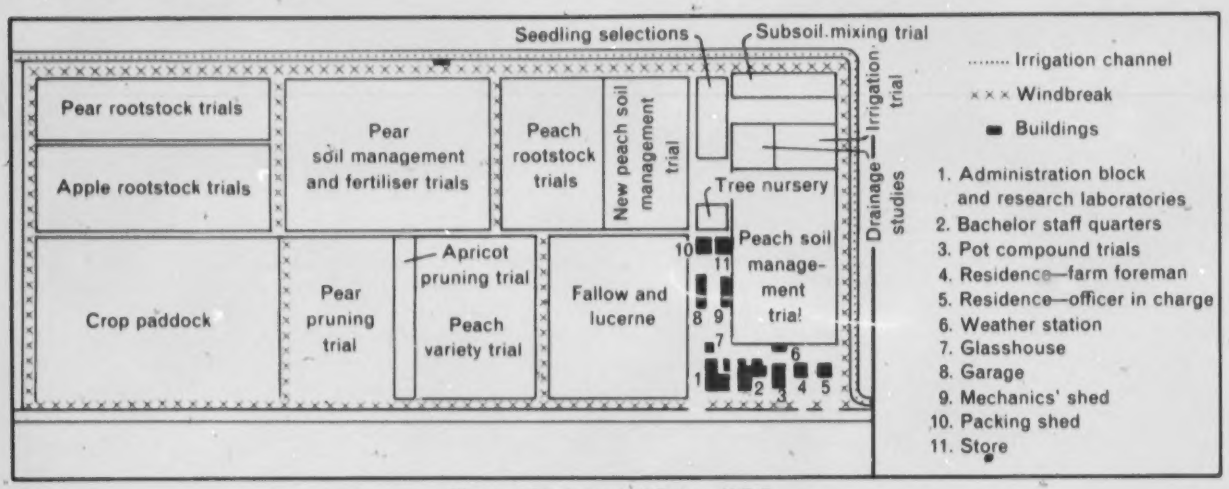


Figure 4.31: Layout of Tatura H.R.S.

Figure 4.32: Dairying and orcharding activities are interspersed throughout the Goulburn Valley

Figure 4.33: On many orchards, especially those worked by immigrant families, row crops of vegetables are grown between newly planted fruit trees. This photograph shows a crop of beans planted with young peach trees. Can you suggest any reasons for this practice?

Table 4.4: Average yields of fruit from Goulburn Valley orchards, 1968–69 season

Fruit	Tonnes per hectare
Apricots	14·5
W.B.C. pears	14·3
Peaches	15·0
Market pears	11·8
Apples	30·3

Source: 'Benefit Study of Additional Water Allocation to Various Forms of Development', part II, State Rivers and Water Supply Commission

Table 4.5: Prices paid to fruitgrowers, 1968–69 season*

Fruit	Price per tonne
Canning apricots	$100
Canning peaches	$93–97
Canning W.B.C. pears	$97
Apples—juice	$27
—processing	$55
Market pears and apples	$35 (domestic)
	$74 (export)

*Fixed by Fruit Industry Sugar Concessions Committee
Source: 'Benefit Study of Additional Water Allocation to Various Forms of Development', part II, State Rivers and Water Supply Commission

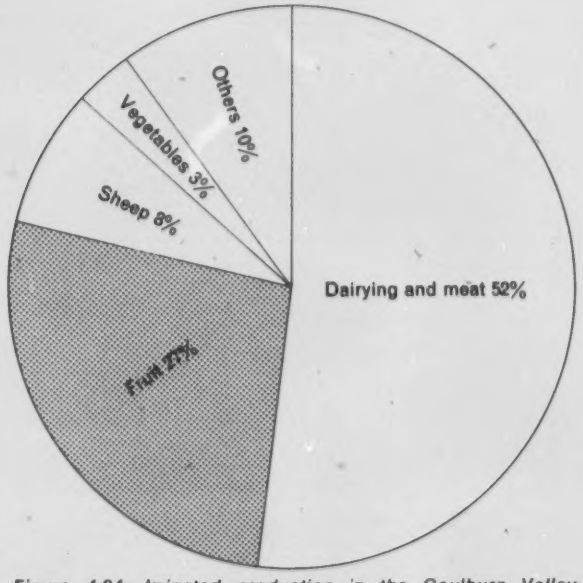


*Figure 4.34: Irrigated production in the Goulburn Valley, 1963–64 (Source: **Victorian Year Book, 1967**)*

Irrigated production in the Goulburn Valley for 1963–64 is shown by pie graph in figure 4.34. Tables 4.4 and 4.5 provide information on average yields for Goulburn Valley orchards and the prices received by fruitgrowers. The total value of all orchard production for the 1969–70 season amounted to $17·8 million.

Mr Spivey's orchard is in the Shepparton Irrigation Area; figure 4.35 shows the nature of irrigated land use in this area for the 1946–47 season.

1. Make a similar graph for the 1968-69 season from table 4.6 and compare the two graphs. Work out the percentage of irrigated area devoted to horticultural crops in each year. How can you explain the difference between the two graphs?

Table 4.6: Irrigated land use in the Shepparton Irrigation Area (hectares), 1968–69

Total area irrigated	Cereals	Lucerne and fodder crops	Pastures	Orchards and market gardens	Other
36 785	120	2145	28 700	5700	120

2. Study carefully table 4.7, and make bar graphs of production for each irrigation area listed. Which area is the major fruit producer? Which is the major pasture and fodder producer? Which is the major market gardening area?

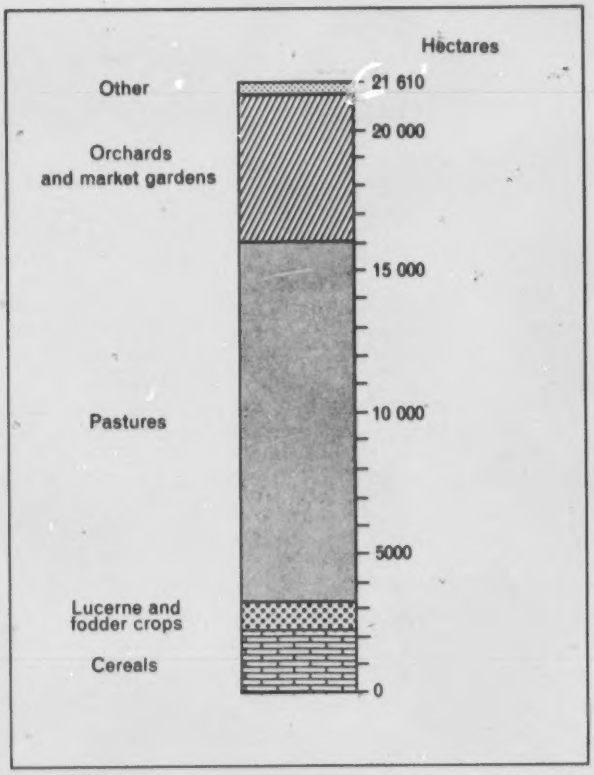


Figure 4.35: Irrigated land use in the Shepparton Irrigation Area, 1946–47

Table 4.7: Irrigated land use in the Goulburn Valley (hectares), 1968–69

Irrigation Area	Total area, irrigated	Cereals	Lucerne and fodder crops	Pastures	Vineyards	Orchards	Market gardens
Shepparton	36 785	120	2145	28 700	40	5380	280
Rodney	65 840	565	4210	54 675	80	4050	1050
Tongala–Stanhope	23 975	120	245	22 800	—	405	160
Deakin	10 895	325	325	9880	—	12	40

3. The following is a list of products from the Goulburn Valley. List each product under the category of land use to which it belongs.

wool	apples	bacon	casein
oats	beans	sweet corn	sorghum
powdered milk	butter	fruit juice	veal
pears	wheat	skins	wine
beef	milk	barley	apricots
potatoes	grapes	plums	hay
sunflowers	cheese	pork	tomatoes
buttermilk powder	peaches	millet	mutton
lucerne	hides	ham	canned fruit

Fruitgrowers in Victoria

Let us now put Goulburn Valley fruit production into the context of the whole of Victoria. Victoria is a major producer of a wide variety of fruits, including pome, stone, vine, berry and citrus fruits. In 1967, nearly 50 000 hectares were used for orchards and vineyards, and these produced almost one-third of Australia's tree fruits and two-thirds of Australia's dried vine fruits.

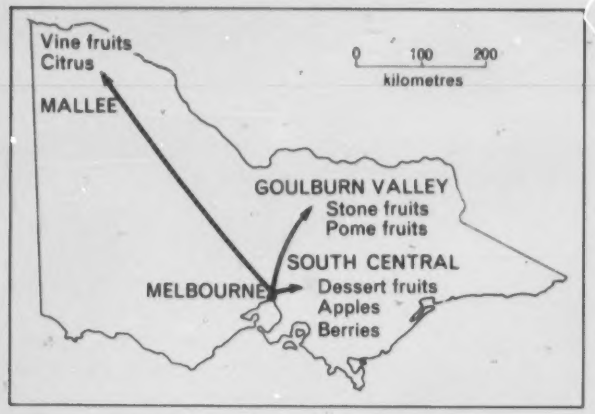


Figure 4.36: Main fruit-growing districts in Victoria

The map in figure 4.36 indicates the most important fruit-growing districts in Victoria. Look up these areas on an atlas map, and also relate them to a land utilisation map of Victoria. A physical map shows that the state is divided geographically into north and south by the Great Dividing Range. This has a significant influence on the character of the fruit industry.

1. Copy and then fill in the climatic charts in figure 4.37. List the fruit varieties grown in each area. Discuss the climatic differences north and south of the Divide in relation to the use of irrigation and the difference in fruit varieties grown.
2. What are the difficulties Mr Spivey faces in his farming operation? Are there any other problems faced by fruitgrowers? For example, in early January 1974 there were heavy rains that threatened to destroy the entire apricot crop. Can farmers offset such seasonal losses?

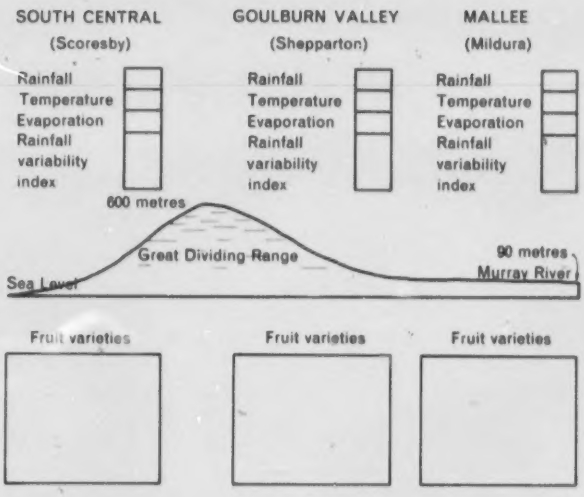


Figure 4.37

5

Sheep, cattle and fruit production in western Victoria

For a long time, we have thought of western Victoria as an area of the world that concentrated on producing wool. Wool is still one of western Victoria's major products, but there are only a few farms with a single type of land use.

'Westgate' farm was selected in 1865 by the great-grandfather of its present owner. The area of the farm is 312 hectares, although its operating size is 494 hectares as the current owner has purchased further land elsewhere. He has also rationalised his farm by selling the awkward south-east corner (see figure 5.1).

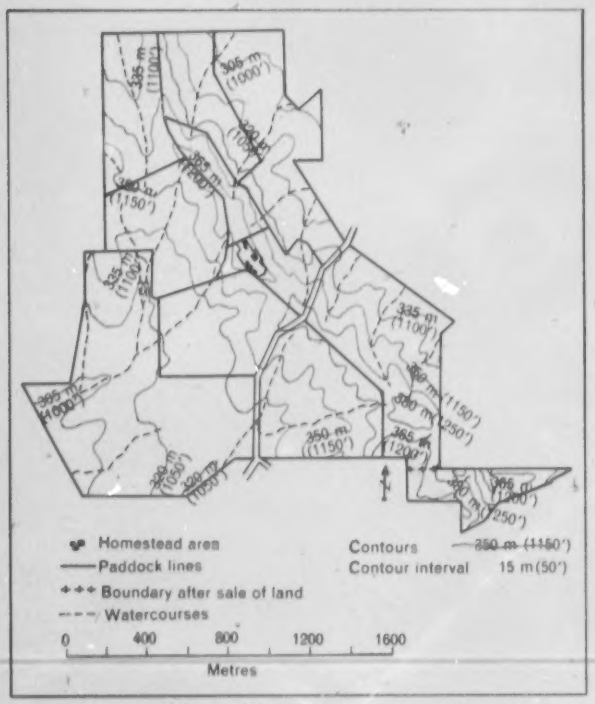


Figure 5.1: 'Westgate' farm

In figure 5.1, you can also see the farm relief as indicated by the contours, the paddocks as in 1950, and the location of the homestead area. Can you suggest any reasons for the pattern of the paddocks and the location of the homestead?

In 1950 the farm was used as shown in figure 5.2 and table 5.1. In 1972 the land use was as shown in figures 5.3 and 5.4, and table 5.2.

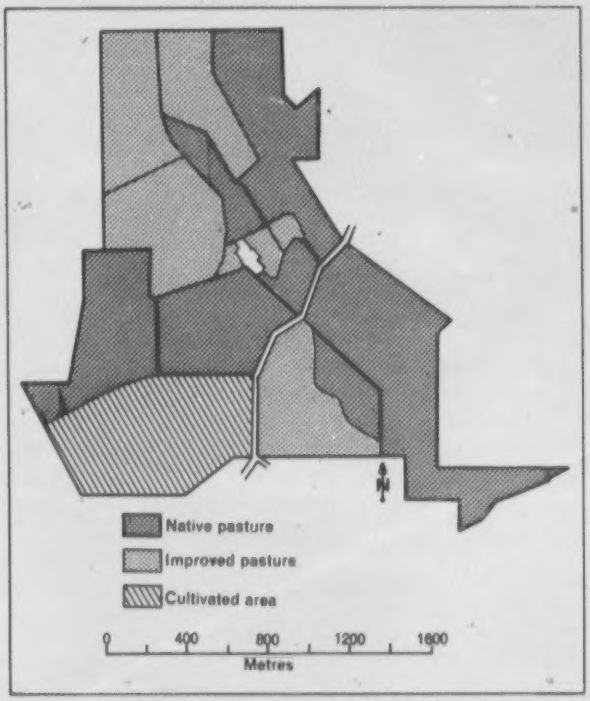


Figure 5.2: 'Westgate'—land use in 1950

Table 5.1: Land use in 1950

Use	Area (hectares)
Improved pasture	94
Native pasture	176
Cultivated	53
Farmyard	1
Total	324

Figure 5.4, the vertical aerial photograph, shows the area cultivated for vines. Identify this area and indicate its extent on the map of farm land use in 1972 (figure 5.3).

In 1947–51, farm production was as shown in table 5.3, and in 1972 as shown in table 5.4.

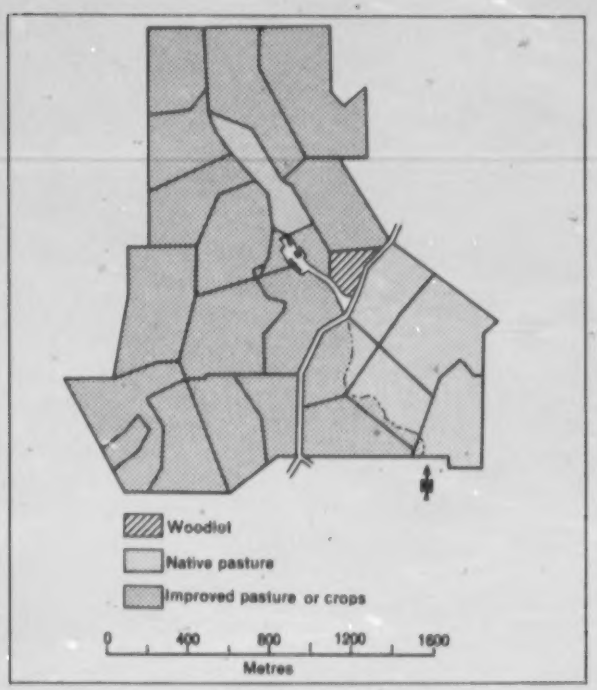


Figure 5.3: 'Westgate'—land use in 1972

The maps, photograph and statistics show that there were some marked changes in the land use and production of the farm over this twenty-year period. What were these changes?

What factors make farmers change their land use and farm production so markedly? Why does the type of production on this property differ from that on the other farms we have looked at? Perhaps we can answer these questions by looking at the ways in which the 'Westgate' farmland differs from the other Victorian farms we have studied.

Table 5.2: Land use in 1972

Use	Area (hectares)
Improved pasture	215
Native pasture	57
Oats for fodder	24
Vines	8
Farmyard	1·5
Woodlot	4·5
Salt-affected	2
(Sold)	(12)
Total	324

Table 5.3: Average annual production, 1947–51

Calves (Jersey)	3
Lambs	250
Wool produced	3175 kg
Wool produced per hectare	10 kg
Sheep (Merino)	1420

Table 5.4: Production, 1972

Grapes	3 tonnes
Calves (Angus)	70
Lambs	1000
Wool produced	13 600 kg
Wool produced per hectare	34–40 kg (est.)
Sheep (Merino–Corriedale cross)	2300

Table 5.5: 'Westgate' rainfall records, as measured on the property (millimetres)

Year	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1939	31·5	50·6	1·0	123·7	76·2	73·7	24·1	93·5	33·8	42·2	81·0	12·4	643·7
1940	21·8	10·2	6·1	56·6	24·8	20·8	47·5	23·6	27·7	24·4	60·5	30·7	354·5
1941	112·0	8·9	44·5	49·8	10·7	63·0	76·2	65·5	91·2	44·7	38·1	29·7	634·3
1942	30·0	36·3	23·6	45·2	102·4	58·4	61·2	94·0	69·9	87·1	59·2	25·2	692·5
1943	26·4	33·8	6·4	30·3	31·0	29·5	57·4	69·1	61·7	27·2	26·7	14·0	413·5
1944	28·7	27·2	5·1	43·9	70·6	10·2	45·2	5·8	27·2	65·8	15·5	56·9	402·1
1945	21·6	47·0	1·0	5·6	37·3	64·8	64·3	88·7	21·6	44·5	57·2	10·9	464·5
1946	120·1	77.5	109·5	34·3	32·5	44·7	108·7	41·7	43·2	22·1	23·9	88·9	747·1
1947	5·8	21·8	109·5	23·9	13·5	71·9	105·7	52·6	54·9	95·5	83·8	56·9	695·8
1948	10·2	14·7	2·8	78·2	38·4	52·3	62·0	26·9	47·2	92·7	37·6	33·5	496·5
1949	12·2	75·4	23·9	4·1	32·0	23·1	59·2	22·1	42·2	90·4	59·2	38·1	481·9
1950	Nil	87·1	56·6	44·7	81·0	11·7	51·8	48·8	83·1	40·4	51·8	16·3	573·3
1953*	22·6	Nil	6·4	34·3	29·7	104·4	98·8	85·3	77·7	53·6	84·8	Nil	597·6
1954	31·8	Nil	6·6	95·3	29·0	38·6	33·0	58·2	40·9	59·2	74·9	97·0	564·5
1955	Nil	50·0	24·9	36·3	47·8	122·4	37·1	179·3	38·9	68·1	24·6	Nil	629·4
1956	22·9	Nil	119·1	83·1	134·9	89·4	87·4	51·3	54·6	42·7	21·3	20·6	727·3
1957	1·5	104·7	48·0	26·4	28·7	39·4	21·6	35·6	49·5	51·3	16·8	8·1	431·6
1958	19·8	7·4	3·8	11·2	115·8	13·7	66·0	76·5	29·7	105·4	68·8	10·4	528·5
1959	20·3	58·2	67·3	30·0	28·5	43·7	24·6	89·9	37·9	56·1	32·5	53·1	542·1
1960	33·0	54·6	35·8	92·5	136·4	47·5	67·6	73·2	94·7	23·9	114·8	18·8	792·8
1961	1·5	19·3	10·9	77·7	20·1	62·7	56·6	36·6	23·1	37·6	27·2	72·6	445·9
Monthly Average	27·4	37·3	34·0	49·0	53·3	51·8	59·7	62·5	50·0	55·9	50·6	33·0	564·5

*Figures for 1951–52 not available

Climate

Table 5.5 shows rainfall records for 1939–61, and table 5.6 shows the percentage chance that Ararat (the closest town to the farm) and Stawell have of receiving rainfall equal to or greater than the 'effective' amount. (Effective rainfall is the amount of rain necessary to start germination of plants and maintain growth above wilting point.) Compare this data with that for the other farms in Victoria. How do climatic factors on the different farms vary?

Table 5.6: Percentage chance of receiving rainfall equal to or greater than the 'effective' amount

	Ararat	Stawell
Jan.	21	14
Feb.	27	19
Mar.	34	26
Apr.	68	59
May	89	80
Jun.	99	94
Jul.	98	96
Aug.	99	93
Sep.	97	87
Oct.	77	64
Nov.	40	31
Dec.	28	18

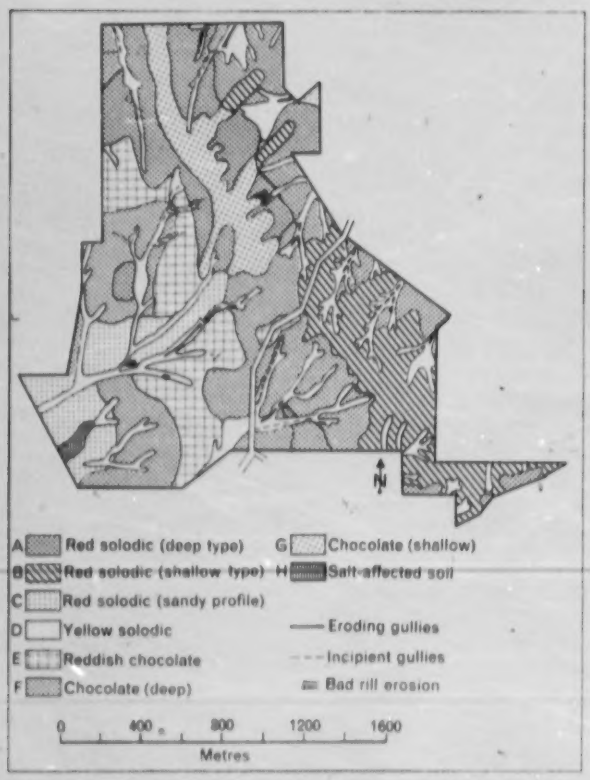


Figure 5.5: Soils and soil erosion on 'Westgate'

Relief

Examine figure 5.1. How does the relief of this farm differ from that of the other farms you have studied so far?

Soils

Read the following extract from a report on 'Westgate' prepared by the Soil Conservation Authority of Victoria.

The soils of the property have been classified into eight soil types, the majority of which are podsolic in character. The distribution of the various soils on the property is shown in [figure 5.5]. Descriptions of the soils, together with comments on those characteristics that could affect land use, are given below.

Types A and B (red podsolic types)

Type A

0–50 mm	Greyish brown clay loam
50–125 mm	Light greyish brown clay loam with quartz gravel
125–350 mm	Reddish brown clay with occasional shale fragments
350–600 mm	As above, yellower, more shale fragments
Below 600 mm	Decomposing shale

Type B

0–50 mm	Greyish brown clay loam
50–225 mm	Light greyish brown loam with heavy amounts of shale fragments
225–300 mm	Decomposing shale

These two types cover most of the eastern and southern portions of the property, including almost all the unimproved country. Type B is an almost skeletal soil found on the ridges and steep spurs above Type A. Both types, which may be described as 'red podsols', are fairly erodible owing to the poor structure of the surface horizons. Because of this, care must be taken when cultivating, as rain beating on the bare soil will readily produce a compacted impermeable layer on the surface. Contour working should spread the surface water evenly and so ensure minimum run-off. The steeper slopes where Type A occurs may not be capable of improvement to any extent because of the difficulty of access. However, if these areas can be topdressed and rabbits eliminated, little further erosion will occur.

Type C (red podsol)

0–50 mm	Grey brown loam or sandy loam
50–175 mm	Light grey brown sandy loam
175–400 mm	As above with medium gravel
400–1250 mm	Yellow grey and reddish brown heavy clay
1250–1500 mm	Decomposing shale

This type is similar to Type A, but the 'A' horizon is deeper and more sandy. Type C is found on gentler slopes than Type A, usually on sites suitable for cultivation. It is considered that this soil would have a relatively high infiltration capacity which would lessen the risk of erosion during periods of a rotation programme when the soil is most vulnerable.

Both the salt-affected areas on the property are found below this soil type; in fact, it would seem that the saline

soil was originally of this type. It is also likely that the existence of saline patches is partly due to the good drainage properties of this particular soil type, enabling the easy seepage of unused water from the higher parts to concentrate in the lower areas, which have become saline.

Type D (yellow podsol)

0–50 mm	Grey brown clay loam
50–150 mm	Light yellowish grey clay loam
150–375 mm	Light yellowish grey and yellow grey clay
375–1050 mm	Yellow grey and brownish yellow clay
Below 1050 mm	Yellow decomposing shale

This soil is found in poorly drained situations, usually in narrow bands along the natural watercourses, and in one or two relatively flat sites. This 'yellow podsol', although usually associated with the 'red podsol' types, also occurs in watercourses in the northern part of the property where the 'chocolate' soils are found. In many places, areas of this soil have been ruined by former gold-mining activities, mullock heaps of raw subsoil and stone having been left over the surface.

Type E

0–150 mm	Brown clay loam with light amounts of quartz stones
150–450 mm	Light reddish brown clay
450–600 mm	Decomposing rock material

Type E is a soil with properties common to both Type A and Type F. The whole profile is redder than Type A, and, although the profile development is not so marked, there is still an appreciable texture change between the 'A' and 'B' horizons. At present this soil type is being used both for improved pasture and for cultivation.

Type F

0–550 mm	Chocolate clay loam with shale fragments
Below 550 mm	Decomposing shale

Type G

0–225 mm	Chocolate clay loam with shale fragments
Below 225 mm	Decomposing shale

These are the so-called 'chocolate' soils, which are found on the ridge running north from the homestead. Type G is the almost skeletal soil found on the ridge and steep spurs, while Type F is the deeper soil found on the lower slopes. There is very little sign of profile development in these soils. The structure appears to be very good, and this is confirmed by the fact that there is little evidence of erosion, except on an old orchard site. Improved pastures have been successfully established on this soil type, and this appears to be the best land use.

Type H

0–250 mm	Greyish brown sandy loam
250–500 mm	Yellow brown clay
500–750 mm	Yellow brown and grey mottled clay
Below 750 mm	As above, with nodular lime

This is the salt-affected soil, of which there are only a few hectares on the property. Bare areas in this saline soil often have a very hard salty crust, and at the time of the survey there was a water table at about 300–375 millimetres depth.

Does the Soil Conservation Authority's report indicate that there are any significant differences between soils on 'Westgate' and those on the other Victorian farms you have studied? If there are major differences, do you think they would be a factor accounting for the difference in types of production?

We have also seen that land use on the farm in 1972 was quite different from that in 1950. Why did the farmer change his use of the land?

When the present owner took over the farm in 1950 from his father, the land was used as shown in figure 5.2. But there was another feature of the farm—widespread soil erosion. From figure 5.5 you should be able to make some guesses as to why the property was in this state. The new owner realised something was wrong (production figures were going down, and the farm's visual appearance was suffering); he therefore approached the Soil Conservation Authority.

The Authority provides an advisory service to landholders for the efficient use and development of their land and the available water resources. To help the farmer achieve permanent, profitable production, its officers conduct surveys and investigations into the nature and extent of soil erosion, and on the basis of their findings make recommendations aimed at overcoming the problem. After completing their survey of 'Westgate', they came to the conclusion that the current land use was reducing the farm's production, and so changes had to occur.

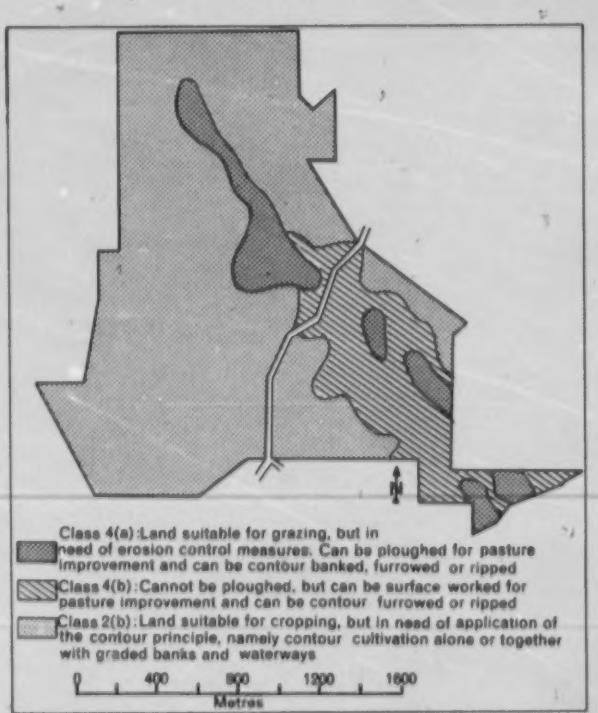

N
Class 4(a): Land suitable for grazing, but in need of erosion control measures. Can be ploughed for pasture improvement and can be contour banked, furrowed or ripped
Class 4(b): Cannot be ploughed, but can be surface worked for pasture improvement and can be contour furrowed or ripped
Class 2(b): Land suitable for cropping, but in need of application of the contour principle, namely contour cultivation alone or together with graded banks and waterways
0 400 800 1200 1600
Metres

Figure 5.6: Land class map of 'Westgate'

First, the S.C.A. officers prepared a 'land class map' as shown in figure 5.6 (see also study 24, page 244). What sort of farming methods did they think were appropriate to the farm?

Second, the officers and the farmer aimed at developing 'Westgate' as a grazing property. They considered that they should restrict the growth of cash crops, which had removed much of the fertility from the farm. As you have seen (tables 5.3 and 5.4), the farmer also changed the types of animals. The Angus beef cattle consume the rank, coarse material in pastures, which sheep will not eat. Also, by changing from Merino to Merino–Corriedale cross he could produce fat lambs as well as wool.

Third, the soil erosion and depletion had to be overcome. You should have some ideas about what had to be done. In the early stages, use was made of contour furrows and banks to reduce run-off, thus preventing sheet and rill erosion and increasing absorption of water in the soil. Pasture improvement was vital, so that the water system could be regained. It involved introduction of subterranean clover and such grasses as rye and phalaris. (Refer to study 24, page 232, for detailed information on soil erosion.)

The result of the programme can be seen in figures 5.7 and 5.8. The land shown in figure 5.8 used to have contour banks, but the soil is now so stabilised that these paddocks can be ploughed, as you can see. Similarly, the farmer now uses only a quarter of the amount of fertiliser that was previously applied.

Figure 5.7: Contour furrowing on 'Westgate', looking north from the 'Ridge' paddock. This drainage line was an incipient and eroding gully in 1950 (see figure 5.5)

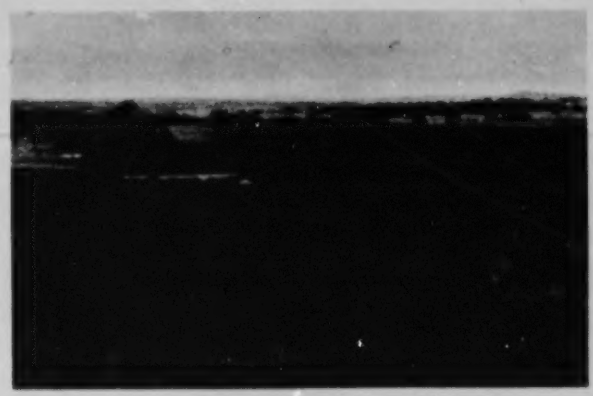


Figure 5.8: Looking due west from the 'Ridge' paddock, with the main supply dam at left

Despite the success of the programme, drawbacks were involved. Contour banks cause some problems, making machinery and vehicle movement very difficult. As well, the high rate of water absorption and transpiration, resulting from the contouring and pasture improvement, has reduced run-off to such an extent that in some years water is short in certain paddocks, and especially in the main supply dam.

Finally, the newest development is the cultivation of grapes. This was not foreseen by the S.C.A., and was a decision made independently by the farmer. Vineyards are a familiar sight in the area, for it is close to the Great Western cellars of Seppelts, who have provided encouragement and advice for the development. The growing market for wine-making grapes has provided motivation for the establishment of new vineyards. But, as you have seen, the local rainfall is hardly sufficient. Here are the farmer's own comments on the remedy he proposes:

> An old mine shaft near the vineyard . . . will produce at 68 000 litres per hour indefinitely. . . . I intend to irrigate the vines with the drip irrigation system. This is a fairly new system—very effective especially where water supply is limited. Each vine is given an equal amount of water daily, during the growing season, by means of polythene piping with a capillary to each vine. I think the requirements are about 9 litres per day per vine. There are 1630 vines per hectare.

This farmer has made a number of changes to his farm, changing the types of agricultural production. Why do you think the changes were made? Is his farm now more efficient? If you think back to some of the ideas in study 1, this may give you some clues to the reasons for change.

6

Fruit production in north-west Victoria

The area to be studied is situated in north-west Victoria, about 16 kilometres south-east of Swan Hill on the Murray River. Find Lake Boga in your atlas; Long Lake is just to the west of it. These are just two of a great number of lakes in the country between Swan Hill and Kerang.

The first European to travel through this area was Major Thomas Mitchell; in 1836 he crossed New South Wales, travelled some distance down the Murray and back again, and then went overland from the vicinity of Kerang to Portland. He was so pleased with the good grass he found among the trees that he called the land 'Australia Felix'. It was not long before squatters drove their cattle and sheep into the newly opened-up land near the Murray—but they soon found that this was not such a 'happy' land as Mitchell had thought. He saw it in June and July. We will soon see why the impressions he gained were misleading.

After rainfall had been recorded for some years, the monthly averages were found to be as shown in table 6.1.

Make a graph to show the monthly figures in table 6.1. Which are the wetter seasons? Would you call this a high, a medium or a low rainfall? (Remember that Melbourne has an annual average of 660 mm, Sydney 1195 mm, Brisbane 1145 mm, Adelaide 535 mm and Perth 890 mm.)

A great deal of water evaporates during the year. If we were to put out an open tank of water in the Lake Boga area we would find that the amounts in table 6.2 would be evaporated.

Make a graph combining the information from tables 6.1 and 6.2 and shade in the part where the evaporation is greater than the rainfall.

It seems that Lake Boga's low rainfall will not last for long in the ground before it evaporates. Of course, the evaporation from the ground will not be as great as it is from the open tank because for much of the time the ground will be dry. We can work out what will be an effective or useful rain from the farmer's point of view by seeing if the rainfall for the month is at least a third of the evaporation for the month.

Work out how many months of effective rain farmers have in the Lake Boga area. How do you think this would affect the growth of grass?

When we studied the farm at Esperance in Level Two, *Space in Change*, we found there were several dry years that had the effect of reducing wool production. Table 6.3 gives the rainfall records for Swan Hill over a long period, and figure 6.1 shows a useful way of plotting the January rainfall from 1885 to 1960—the rainfall for January each year is noted on the diagram, and we then mark the average and the mean (or middle point). Thus we can easily count the number of years receiving less than half the average rainfall or less than a quarter of the average—or any other figure we want to find out.

Make a dot diagram for the other months in the manner described. Are there more years with above or below average rainfall? Which months have the most reliable rainfall and which the least reliable? (Count the dots that are close to the average.)

Table 6.1: Average monthly rainfall (millimetres)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
16·3	20·1	21·1	24·1	34·3	40·1	28·2	34·0	33·5	30·2	23·6	29·2	334·7

Table 6.2: Evaporation losses (millimetres)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
165·1	129·5	109·2	66·0	40·6	30·5	30·5	38·1	61·0	88·9	116·8	147·3	1023·5

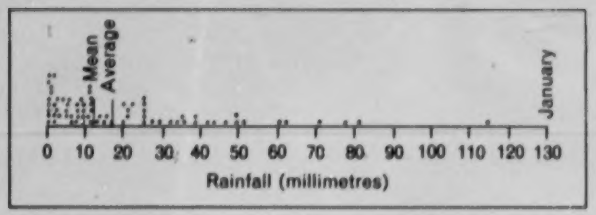


Figure 6.1: Scattergram of January rainfall at Swan Hill, 1885–1960

From your diagrams and the totals shown in table 6.3, would you class this as a reliable or an unreliable rainfall? (By way of comparison, the highest, lowest and average annual rainfalls at Esperance Research Station are 686·8, 259·1 and 463·8 millimetres respectively.)

Would this information be of help to farmers? How? Write a paragraph to sum up all you have learnt about the rainfall in this area.

Although the rainfall is quite unsatisfactory for farming, the soils are generally rich and easily worked, while temperatures are suitable for growing many types of commercial crops. Average maximum and minimum temperatures are shown in table 6.4.

Would you describe the summers as hot, mild or cool? Would you describe the winters as mild, cool or cold? Most plants stop growing if the average temperature for a month drops below 6·1°C. Would plants grow throughout the year here? Would you expect frosts to be frequent

Table 6.3: Swan Hill—monthly rainfall (millimetres), 1885–1960

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1885	6·3	11·4	6·6	6·4	38·6	30·0	11·2	15·8	58·9	10·2	2·0	82·3	279·7
1886	4·6	38·1	15·2	67·6	8·9	56·9	37·1	72·4	47·0	18·3	11·2	76·2	453·5
1887	34·8	Nil	4·3	Nil	21·3	10·2	57·7	43·7	35·6	33·8	84·6	72·9	398·9
1888	6·4	19·1	30·7	19·1	27·2	38·9	22·1	16·3	23·4	10·9	Nil	10·4	225·0
1889	44·5	46·0	Nil	113·8	69·6	23·9	Nil	63·5	35·6	11·9	55·4	0·8	465·0
1890	4·3	26·9	33·3	6·6	53·1	47·8	59·4	39·6	21·3	45·7	58·9	18·0	414·9
1891	24·6	Nil	32·3	82·3	13·5	57·2	14·7	32·5	7·9	82·0	32·5	8·4	387·9
1892	0·8	6·6	4·8	11·7	72·1	35·8	35·3	38·6	49·5	71·1	27·9	8·1	362·3
1893	3·1	Nil	11·4	33·3	51·6	60·5	20·8	35·8	25·9	10·4	64·5	5·1	322·4
1894	23·9	1·8	57·2	4·8	20·6	84·1	30·5	71·9	17·5	81·8	10·9	133·1	538·1
1895	32·5	6·6	6·6	57·7	2·0	34·8	29·7	33·8	26·8	16·0	Nil	49·3	295·8
1896	11·2	28·5	46·7	26·2	22·1	24·1	13·5	24·4	34·3	2·5	15·2	23·1	271·8
1897	70·8	Nil	8·1	4·8	3·8	46·7	22·6	46·0	32·3	12·7	2·5	3·8	254·1
1898	Nil	18·3	Nil	19·6	25·4	68·8	30·7	51·8	16·3	20·3	6·9	22·6	280·7
1899	24·4	30·7	37·9	29·2	13·2	91·4	16·0	13·0	9·4	16·0	31·8	Nil	313·0
1900	2·5	Nil	38·1	39·9	50·6	40·9	17·3	37·1	28·2	6·6	19·6	8·9	289·7
1901	10·4	10·4	Nil	42·7	4·8	25·7	30·0	37·1	40·4	33·8	19·8	10·4	265·5
1902	6·4	0·5	19·1	7·1	2·8	34·3	6·1	12·2	14·2	30·7	6·1	42·2	181·7
1903	Nil	9·9	26·2	54·4	18·8	39·6	58·4	2·0	72·4	21·1	59·4	49·0	411·2
1904	62·0	Nil	3·6	17·5	14·2	19·6	41·9	31·5	5·6	64·5	18·8	6·4	285·6
1905	27·9	Nil	Nil	115·1	32·5	24·6	49·0	9·4	27·7	36·3	2·5	6·4	331·4
1906	Nil	21·8	90·7	0·3	103·6	44·7	24·6	41·2	63·0	22·1	32·0	9·4	453·4
1907	Nil	4·8	2·0	12·2	9·1	17·5	39·1	23·4	3·3	5·6	35·8	37·3	190·1
1908	7·9	11·9	10·4	2·5	27·4	53·9	16·8	32·0	26·4	27·4	4·8	10·2	231·6
1909	10·9	13·2	15·5	12·2	80·8	53·9	24·4	59·9	14·0	8·9	9·4	3·8	306·9
1910	25·9	17·3	43·2	0·8	37·3	44·7	45·7	24·6	43·9	33·0	45·0	17·8	379·2
1911	8·1	116·3	32·0	Nil	52·3	35·6	21·3	10·2	34·3	6·4	1·8	54·4	372·7
1912	6·4	16·0	1·0	0·5	Nil	77·0	30·7	47·2	35·6	6·6	23·1	41·7	285·8
1913	3·1	2·8	71·9	15·0	67·8	15·5	12·5	11·2	49·5	55·6	2·3	27·9	335·1
1914	1·3	12·7	18·8	37·9	19·6	3·3	5·3	0·5	1·0	Nil	16·5	59·7	176·6
1915	12·7	Nil	Nil	15·5	37·3	45·0	27·4	46·2	58·9	20·8	3·8	5·8	273·4
1916	33·8	7·4	1·8	5·6	21·3	64·0	49·3	35·6	87·9	51·6	8·6	24·9	391·8
1917	37·3	85·3	10·9	3·1	36·3	43·4	50·0	72·6	80·5	97·8	77·0	9·7	603·9
1918	19·3	75·4	88·7	25·7	95·0	36·6	7·9	54·4	8·4	17·5	12·2	10·4	451·5
1919	3·1	65·5	25·4	19·3	66·0	29·2	11·2	15·0	42·2	10·4	10·4	36·6	334·3
1920	5·3	Nil	2·5	9·9	29·0	26·9	27·9	81·0	78·5	64·3	18·3	20·8	364·4
1921	20·1	3·1	24·6	5·8	60·7	43·2	25·9	35·3	64·5	11·9	22·1	48·0	365·2
1922	2·0	3·3	Nil	25·2	26·7	27·2	18·0	15·0	32·3	32·8	Nil	22·6	205·1
1923	20·1	Nil	Nil	Nil	34·8	136·7	86·6	22·1	24·4	18·5	22·4	55·6	421·2
1924	15·3	19·6	27·9	19·6	11·9	32·8	3·1	50·6	27·4	42·4	55·1	40·9	346·6
1925	10·9	26·7	7·4	3·6	66·8	26·7	26·7	45·0	32·0	3·8	26·9	Nil	276·5
1926	1·0	Nil	63·3	62·7	46·7	25·4	31·0	23·1	30·0	25·2	1·8	27·2	337·4
1927	6·6	4·6	3·3	Nil	20·3	9·4	40·9	22·4	10·2	32·8	14·0	6·1	170·6
1928	81·0	86·6	27·2	27·2	16·8	31·5	15·2	7·4	35·3	42·7	3·6	1·0	375·5

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1929	3·3	23·9	14·7	34·5	7·4	17·8	8·1	17·5	11·2	21·6	24·9	48·3	233·2
1930	Nil	15·8	13·2	4·1	40·4	6·6	35·3	46·0	17·3	88·4	23·1	93·0	383·2
1931	14·2	Nil	41·7	57·2	63·8	78·5	24·1	5·3	40·6	19·1	32·8	Nil	377·3
1932	0·3	78·2	32·8	81·8	27·7	51·6	36·1	50·8	23·1	12·5	3·6	22·4	420·9
1933	49·8	Nil	19·1	5·1	33·5	28·5	48·8	32·3	41·9	17·0	28·5	45·5	350·0
1934	8·9	57·2	11·9	37·6	Nil	7·1	21·8	29·5	13·0	83·3	44·5	2·8	317·6
1935	13·5	15·5	14·0	30·5	4·1	16·8	39·1	20·8	34·5	62·0	11·9	5·4	268·1
1936	48·0	Nil	2·0	11·7	45·7	38·9	94·7	29·2	8·4	18·5	3·3	46·7	347·1
1937	52·3	17·5	1·0	1·8	25·4	33·0	11·2	34·0	5·6	77·7	3·1	11·9	274·5
1938	31·2	13·7	Nil	7·4	3·8	27·7	38·9	26·9	Nil	4·0	1·8	0·5	155·9
1939	1·3	102·1	26·9	28·7	47·5	38·4	32·3	23·6	33·3	25·2	64·8	1·3	425·4
1940	7·9	Nil	2·5	28·2	5·1	5·8	23·9	7·4	46·2	1·3	18·0	4·8	151·1
1941	60·7	5·1	35·8	0·8	1·8	12·7	40·4	18·0	41·9	35·8	17·8	14·2	285·0
1942	11·4	38·4	15·8	16·0	41·2	48·3	26·9	62·7	11·2	26·4	35·5	10·7	344·5
1943	0·5	5·3	0·3	21·3	3·3	17·0	15·0	29·7	23·4	37·9	16·8	4·8	175·3
1944	4·3	0·8	1·0	28·2	31·2	2·0	18·3	0·3	5·8	20·3	18·3	34·0	164·5
1945	7·9	2·8	4·3	Nil	9·7	69·3	12·7	44·2	9·7	51·8	24·4	16·3	253·1
1946	76·7	93·2	23·1	42·9	40·4	32·8	40·9	26·4	6·4	9·9	33·0	29·5	455·2
1947	15·2	26·9	48·8	Nil	6·6	0·3	38·6	22·9	23·1	61·5	50·8	25·7	320·4
1948	2·8	3·1	Nil	29·2	33·0	12·7	10·4	5·8	21·8	61·5	23·4	53·3	257·0
1949	10·7	Nil	39·9	Nil	51·8	14·7	48·0	7·9	36·8	76·2	25·4	Nil	311·4
1950	Nil	55·9	65·5	10·7	32·8	21·1	36·1	11·4	25·4	40·6	38·9	12·5	350·9
1951	20·6	21·6	5·8	28·5	89·2	85·1	41·2	40·1	Nil	19·1	0·8	2·5	354·5
1952	10·7	9·9	25·7	34·3	103·1	15·5	15·2	Nil	22·6	78·2	28·2	13·0	356·4
1953	19·6	9·1	Nil	21·6	9·4	31·5	33·3	53·3	37·1	36·3	27·4	2·5	281·1
1954	50·0	1·0	6·4	56·4	9·7	8·9	19·1	31·2	15·8	Nil	56·4	73·7	330·6
1955	Nil	77·0	54·9	5·6	24·9	31·5	61·5	44·7	52·8	34·5	29·2	16·6	433·4
1956	42·2	4·3	87·6	38·4	132·6	42·7	78·7	32·8	36·6	80·0	25·4	Nil	601·3
1957	0·8	59·2	32·0	7·4	2·0	47·8	23·4	30·7	8·1	11·4	8·6	8·6	240·0
1958	24·1	18·3	1·5	8·1	58·2	4·3	44·7	77·7	18·3	84·6	38·1	2·8	380·7
1959	36·8	9·1	12·2	10·9	8·6	16·8	6·6	16·8	19·3	106·7	7·4	25·7	276·9
1960	114·8	27·9	10·4	30·2	57·7	16·8	69·3	35·6	60·5	4·1	57·9	21·3	306·5

Highest annual rainfall: 1917, 603·9 mm Lowest: 1940, 151·1 mm Average: 328·7 mm

Table 6.4: Average temperature (°C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Maximum	31·6	32·1	28·1	23·4	18·4	14·6	14·4	16·2	19·5	23·3	27·6	30·7	23·3
Minimum	14·9	15·7	12·4	9·4	6·7	4·5	3·7	4·3	6·3	8·8	11·7	13·8	9·3

or severe in winter? Why? Add these temperature records to your graph of rainfall and evaporation.

It is not surprising that farmers very soon realised they could produce much more from the land if they had water with which to supplement the natural rainfall. Long Lake today lies in the centre of three different water-supply systems and has been involved in all of them.

First came the wheat farmers. When stump-jump ploughs, seed drills and harvesters were invented, it became possible to grow wheat in places where the yield per hectare was low. The Mallee country around Swan Hill received just enough rain in most years in winter and spring for wheat to be grown and harvested before the hottest and driest part of the year. But there was not enough water for the farm families, and especially for the large teams of horses they needed to pull their ploughs and harvesters. If you look at your atlas you will see that the northward-flowing rivers dry up and there are no permanent creeks.

All kinds of methods of getting water were tried. Near the South Australian border, bores yielded water. Some farmers dug deep storage holes and covered them over to prevent evaporation; others even sank iron tanks to hold water; some cleared large shallow catchments; others even laid sheets of iron on the ground to make more water flow into the catchments. But none of these methods was really satisfactory, so engineers were called in to construct channels to bring water in from other places. One of the early supplies, in 1904, was from water pumped out of Long Lake through a 45 centimetre spiral-riveted steel pipeline to 1500 square kilometres of Mallee country. (This pump now stands on the roadside at the edge of Lake Boga.) Then reservoirs were constructed in the Grampians and on the Goulburn River at Eildon, and water flowed from these for hundreds of kilo-

metres to fill farmers' dams in the Mallee. Your atlas maps will show these reservoirs. All the water now comes from the Grampians, but it does not go into the Swan Hill area.

Farmers close to the Murray could pump water from the river, and this is what is done near Swan Hill and Nyah: a large pump supplies enough water to the channels for the farmers to irrigate their land and grow fruit or fodder for animals. This area lies to the north of Long Lake.

The third method of getting water was employed further upstream on the Murray. By putting in a weir at Torrumbarry the river level was raised high enough for water to flow along a channel south of the Murray, and then to irrigated orchards and farms. Extra storages were created by bringing Murray water into lakes and swamps like Kow Swamp and Lake Boga. This supply came right up to Long Lake. You can also trace this scheme in your atlas.

On a map of Victoria, draw in the three areas concerned, name the storages and weirs, and show the direction in which the water flows.

As a result of all these very skilled engineering works, the huge grazing runs could be cut up into small farms, thousands more farmers used the land, and production was increased tremendously. All this has been very successful, but there have been some unexpected results—new problems have been created, calling for more scientific investigation.

Let us now look at Mr Hamden's farm, on the south-west side of Long Lake (see figure 6.2). The property consists of three blocks, with a total area of 142 hectares. Note the large blocks of other farms in the wheat area to the west; the moderate blocks in the north, irrigated with pumped Murray water; the small fruit blocks south of Lake Boga and the moderate blocks in the east, both irrigated with water flowing from Torrumbarry Weir.

The oblique aerial photograph, figure 6.3, looks over the property, including part of Long Lake (right) and Salt Lake (left).

Draw a field sketch of the photograph, including a north pointer, the outline of the farm, and the house. Which part of the farm is not shown? Describe the land surface. What evidence is there of low rainfall? In what season of the year would this photograph have been taken? What evidence is there of irrigation? Does it appear that the whole area is irrigated?

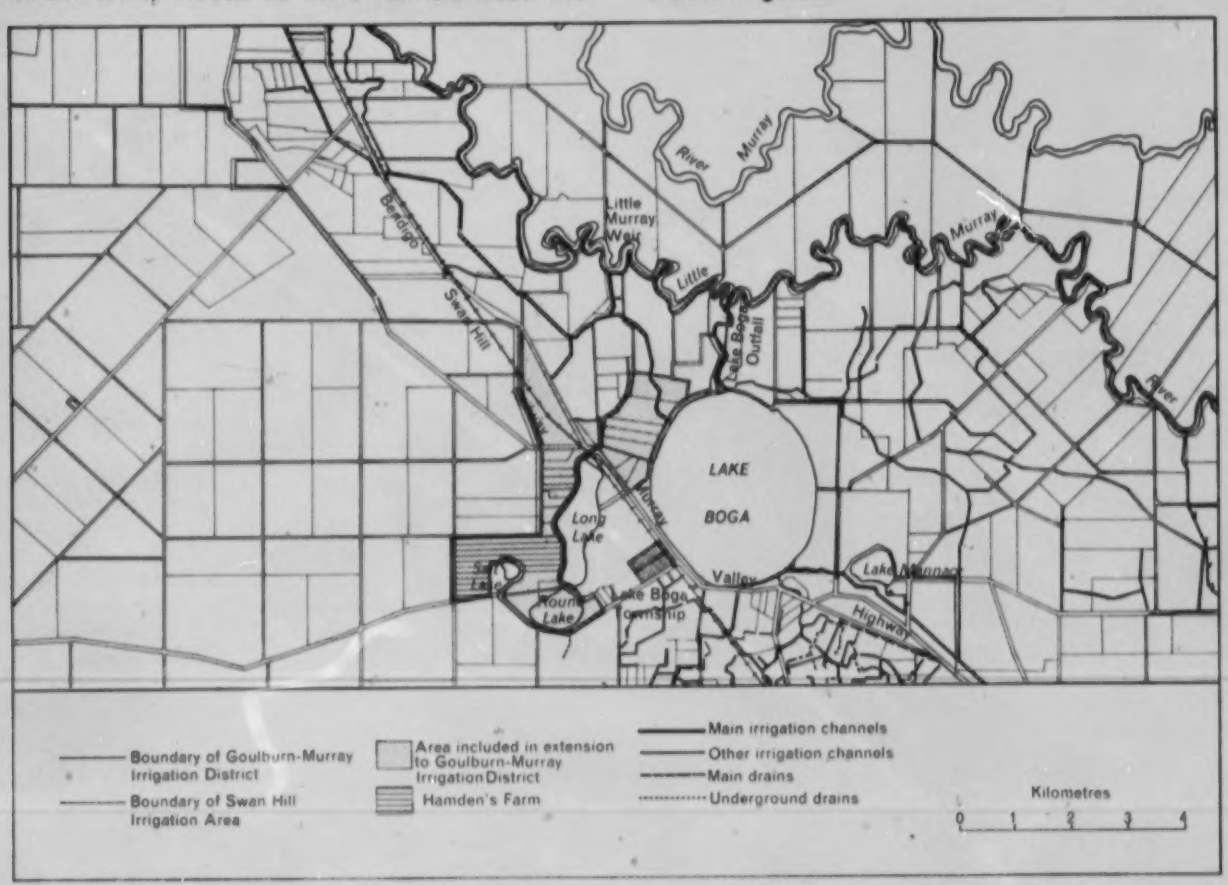


Figure 6.2: Subdivisions in the Long Lake area (Source: State Rivers and Water Supply Commission, Victoria)

Figure 6.3: Aerial photograph of Mr Hamden's property, 1962

Figure 6.4: Fallowing wheat land—note the colour of the soil. In which season is the land fallowed? What indication of the weather is given by the clouds in this photograph?

Figure 6.5: Delivering wheat to the silo at Swan Hill railway station. Try to find out the stages in the journey of the grain from the farm to the wheat terminal at Geelong. Why is the method of transport cheap?

Figure 6.6: Portable spray lines for irrigation

Figure 6.7: Spraying fruit trees—what sprays are used?

The farm has been in Mr Hamden's family since just after 1900, and was first used by them for wheat growing (figures 6.4 and 6.5).

After World War I the son of the original farmer took the first steps in intensifying production. He set up a private pumping scheme, with a steam-driven engine to pump water from Long Lake into a concrete channel and then into smaller concrete channels for delivery to the land. As a result of this engineering project a citrus orchard was planted. In the early 1930s a channel was cut through the sandhills east of Long Lake so that water from Lake Boga could flow into Long Lake Channel and keep up the supply. But Long Lake very soon became salt, so unemployed men were put to work during the Great Depression to cut a channel by hand around Long Lake to deliver water from Lake Boga to the Long Lake farmers. This was the extreme point of the Torrumbarry Weir water supply.

There was now an assured water supply, but the citrus trees declined in health after some years. Investigations showed that the salt content of the water was increasing. It was found that there were several causes for this. The lakes in this dry part of Victoria need to be flushed out with flood waters every few years to get rid of accumulating salt; however, this did not happen after irrigation started. Every year since 1958, about one metre of Lake Boga has been run out into the Murray in May and replaced by less saline Murray water in September, but this has been only partly successful. In this dry country the permanent groundwater in the soil is naturally very deep—at a depth of about 4 metres—and because of the geology of the area the groundwater is salty. Once irrigation started the groundwater began to rise, partly because farmers put too much water on their land, and partly because water seeped out of the irrigation channels into the soil. Consequently the ground-water sometimes seeped up into the channels. A further reason for the heightened salinity is the increased drainage work undertaken on farms today. The drainage water is usually saline and is run into the rivers supplying the irrigation water. Thus Lake Boga, at the end of the line, often received rather poor-quality water.

To help overcome this problem, the present owner switched over from flood or furrow irrigation to spray irrigation (figure 6.6). His land was so sandy that the water soaked in quickly; with flood irrigation, this meant that uneconomic amounts of water had to be put on for the trees to get enough, and the extra water tended to raise the water table. The experience of other farmers in the district had already confirmed the dangers of flood irrigation—their land became salty and their trees died. There were additional reasons for switching to spray irrigation. It was possible to spread the water evenly and control the amount the trees received, and the farmer could grow pasture for animals between the fruit trees, thus double-cropping the land. As water was no longer wasted, the orchard could be extended without having to level the land as for flood irrigation, and some very suitable sand-hills, which could not be reached by flood irrigation, could now be planted.

Like most improvements, spray irrigation was very costly to install and to run. The permanent spray system would have cost over $1200 per hectare to install if outside labour had been used. Mr Hamden cut this to less than $500 per hectare by doing the work himself. The spray system requires a pump, and in 1970 the electricity for this cost $600.

Trees are planted 300 to 400 per hectare and cost 75 cents each to buy. Mr Hamden, however, grew most of his trees from seed and grafted the seedlings with the varieties he required. Two other major costs in establishing the orchard were $2500 for a spray cart, and $5000 for a packing shed and its equipment. Mr Hamden has applied the results of scientific research to control the worst pest of citrus trees—red scale. Some years ago he obtained some imported wasps that eat red scale. These keep the scale under control on his orchard, and save $1000 a year on oil spray, which is the only other way to control the pest (figure 6.7).

It is not only cost that sets a limit to the size of an orchard. The farmers are given an annual water right, which in Mr Hamden's case is 283 700 cubic metres, and if there is plenty of water in the storages they may buy extra water. Scientists have worked out that a mature citrus grove in this area will need 750 to 900 millimetres of irrigation water a year if it is to produce well.

Calculate how many hectares of this farm can be irrigated for citrus trees. Why would it be foolish to rely on buying extra water in excess of the water right?

All went well with the spray irrigation system until 1964. Figures 6.9 and 6.10 were taken within two or three weeks of each other and show the same trees on the orchard adjoining Mr Hamden's. Describe the change that had taken place.

This disaster occurred at the end of November 1964. The winter before had been very dry, so the trees absorbed a great deal of water when they were spray irrigated; however, the salt content of the water had risen too high. The citrus trees absorbed so much salt through their leaves and roots that the leaves and young shoots shrivelled and died. These trees may never return to full production. As a result of this experience the orchardists appealed to the State Rivers and Water Supply Commission (S.R.W.S.C.) for an improved water supply. By 1968 a new source of water was operating, as shown in figures 6.2, 6.8, 6.11 and 6.12. Describe how the water has been made to flow into the channel from the Little Murray River.

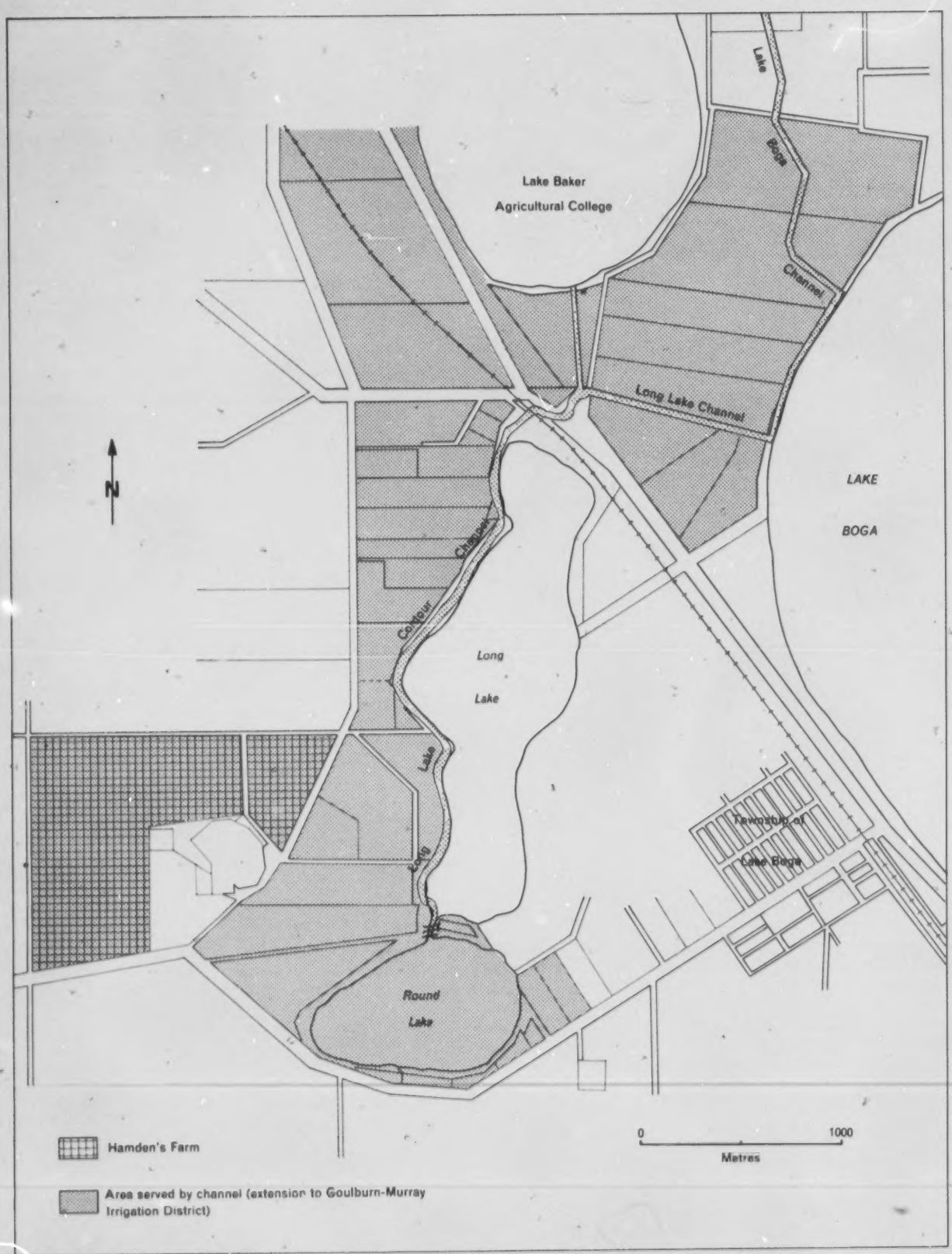


Figure 6.8: Water supply to farms in the Long Lake area—see also figure 6.2 (Source: State Rivers and Water Supply Commission, Victoria)

Figure 6.9: Orange orchard before salting

Figure 6.10: The same orchard as in figure 6.9, after the disaster of November 1964

Figure 6.11: Aerial view of the Little Murray Weir

Figure 6.12: Water supply channel near the Little Murray Weir

Figure 6.13: The forager and trailer cutting a field of lucerne. Describe how this equipment works

Figure 6.14: Feeding cattle in the feedlot. Describe the whole operation

Figure 6.15: Feedlot and hayshed

Figure 6.17: The manure spreader in action. What is the capital cost involved in spreading manure? What benefit does the farmer get from this operation? Why does he have such a large supply of manure?

Figure 6.16: Picking up manure to load it into the spreader

Figure 6.18: A windbreak of Murray pines. Why do these trees grow so well? What are the benefits of using land in this way?

This scheme was an improvement, but there is still a potential source of contamination of the water, resulting from technical developments on other farms. To prevent the level of saline groundwater from rising, farmers now put deep drains into their irrigated land. Over 70 per cent of the drainage water from the Kerang–Cohuna area goes into the Murray and this drainage water is likely to be salty. Nearer at hand, the Long Lake farmers who flood-irrigate have put in drains, and as the new channel is very deep in places and passes through very salty country it picks up some of this drainage water. As a result, the water in the supply channel often records 300–500 parts per million (ppm) of salt—and 250 ppm is reckoned to be as much as citrus trees can stand without damage. Engineers have found that pumps are more effective than drains in getting rid of saline groundwater, and they are also diverting the worst creeks into already salty lakes; but the problems for the individual farmer who uses this technique of irrigation are by no means over.

Mr Hamden hasn't any salting problem on his farm, but he does face another serious difficulty. Table 6.5 compares his main running costs and his returns from fruit over the last eight or ten years. Note that there are no costs for labour (Mr and Mrs Hamden did all the work), fertiliser and sprays (for reasons we will see later), or interest on loan money.

Table 6.5: Fruit growing—costs and returns

COSTS	1962	1970
Electricity (power for pump)	$650	$600
Freight	120	226
Fuel and oil	360	610
Insurance	54	197
Rates	154	766
Repairs to machinery	146	785
RETURNS FROM FRUIT	**1960**	**1970**
Average price for early fruit per case	$4·00	$2·40
Less costs of marketing:		
Packing (labour, power, depreciation)	·10	·45
Container	·18	·43
Freight	·21	·30
Commission (1960—10%; 1970—15%)	·40	·36
Net return per case	3·11	0·86

Work out by what percentage the costs rose from 1962 to 1970. Work out what percentage of the 1960 returns Mr Hamden received in 1970. Draw a diagram to show these two trends clearly. Why could no farmer carry on for long under these conditions? Is there any way out of this situation?

One change did occur in selling methods in 1970. The main crop sold at much lower prices than the early fruit—at from $1.20 to $1.80 a case. Mr Hamden sold most of this fruit to a man who came to the orchard, for $1.20 a case, and thus he saved freight, commission and some of the container cost. But this would not apply to a large crop.

The real solution Mr Hamden has found is to use scientific knowledge and technology still further and start raising cattle on feedlots. This came about partly through the falling prices for fruit, rising costs, uncertainty about the quality of the water, and also the impossibility of getting good and reliable labour. Mr Hamden noticed how well lucerne grew in the district—the alkaline sandy soil, the heat and the abundant irrigation water all suit it very well. Lucerne also has a high salt tolerance. But growing lucerne for sale would be unreliable, as farmers would not need to buy it in good years. Then came the drought of 1966 when cattle and calves could be purchased cheaply—so here was the answer: grow lucerne and fatten cattle on it. However, there were still problems to be overcome: lucerne cannot be grazed by cattle for long periods, though it can be cut many times a year. Also, cattle are likely to suffer from bloat if they graze on lucerne. Moreover, the fences were not strong enough for cattle, and the animals would soon damage the spray irrigation system. Thus it was decided to keep the cattle on feedlots—small paddocks to which the feed is brought after it has been cut. A good deal of extra equipment was needed (table 6.6). By doing all the construction work himself and reusing materials, Mr Hamden saved at least $2000.

Table 6.6: Extra equipment and costs for the feedlot programme

Forage harvester to cut feed (second-hand)	$200
Two-tonne feed cart with side-unloading attachment	$1550
Feedlots (built of materials on the farm)	—
Drinking troughs (from old 44-gallon drums)	—
Two grain silos (36 m^3 capacity each)	$74
Roofing (reused materials)	$60
Auger and electric motor to handle grain	$86
Three dams for watering stock (used in winter when channels do not flow)	$285
Electric fence and power unit (used on wheat land)	$234
Manure spreader	$1600

Look carefully at figures 6.13 and 6.14 and write a description of the day-to-day tasks involved in feeding the cattle.

Look then at the monthly work plan (table 6.7) and from the last column make a list of the different kinds of fodder harvested during the year.

From the third column find the reasons why fewer cuts of forage are made in winter than in summer. Forage cannot be cut when the weather is wet; what provision is made for feed on those days? (Figure 6.15 will help you to answer these last two questions.)

Table 6.7: Work plan

N.B. Irrigation is the same for orchard, lucerne and millet.

	ORCHARD		CATTLE	
	CITRUS	APPLES	ACTIVITIES	FORAGE (Hours per day and type)
JANUARY	Irrigate 100–125 mm.	Spray for codling moth. Pick early Gravensteins.	Drench and spray. Plant millet for autumn forage. Selling bulls fortnightly until end of August.	4 lucerne
FEBRUARY	Pick Valencias. Irrigate 75–100 mm.	Spray for codling moth. Pick Jonathans and Golden Delicious.	Calving in no definite pattern until October. Irrigated oats for winter forage.	4 lucerne
MARCH	Apply superphosphate. Trace-element spray (zinc, copper, lime, manganese). Irrigate 75 mm.	As for citrus.	Plant early oats underseeded on 80 hectare paddock (done by share farmer). Selling of bulls reaches a peak.	4 millet, lucerne
APRIL	Pick lemons. Irrigate 50 mm.		Trace elements on pasture. Plant oats for hay and reaping.	3 millet, oats, lucerne
MAY	Pick early oranges, which need gassing. Irrigate 40 mm.		Heifers and breeder cattle go to 80 hectare paddock. Fatteners placed on binstacks as pasture growth slows down. Plant wheat (done by share farmer).	2 barley oats,
JUNE	Pick Washington navel oranges. Spread cow manure from June to August.	Spread cow manure from June to August.	Start to feed hay reserves with green chop-fodder. Spread cow manure on pasture from June to August.	2 oats, barley
JULY	Pick Washington navel oranges.		Calving reaching a peak.	2 oats, barley
AUGUST	Pick Washington navel oranges. Irrigate 40 mm.	Prune apple trees.	As cattle calve they are brought in to two feedlots. Hay reserves all used. Drench and spray.	3 oats, barley, phalaris
SEPTEMBER	Pick Washington navel oranges. Irrigate 65 mm.		Superphosphate on pasture. Spray wheat (done by share farmer).	3 spring growth, phalaris
OCTOBER	Irrigate 75 mm.	First spray after blossom for codling moth.	Reap and bind oats, barley. Binstack excess spring growth.	4 spring growth
NOVEMBER	Irrigate 90 mm.	Spray for codling moth once a fortnight.	Bale hay (oats) and cart sheaves and bales.	4 lucerne
DECEMBER	Irrigate 100 mm.	Spray.	Compulsory drench—strain 19 (brucellosis)—by government of all heifers under eight months. Harvest wheat (by share farmer).	4 lucerne

The aim of the feedlot programme is to be able to sell young bulls when they are eight to nine months old. The butcher must cut about 130–180 kilograms of meat from the carcass, and for this to be done each vealer must weigh between 270 and 320 kilograms. This means the animal gains about one kilogram in weight per day during its life. The farmer gets 60–70 cents per kilogram for each vealer, and the beasts are sold to local butchers, or in Melbourne through agents. Marketing costs are extremely low by comparison with fruit (see table 6.8). Work out how much the butcher pays, and how much the farmer receives for each animal after marketing costs are deducted.

Table 6.8: Cattle marketing costs

Cartage to market	$1.20 per head
Stock agent's fees	5% of gross price
Yard dues, beef levy, stamp duty, all less than . . .	1% of gross price

The number of cattle raised has increased year by year. In 1970, ninety-five cows and heifers calved and about forty-five vealers were sold. However, to produce this return the cash inputs are high (see table 6.9).

Table 6.9: Cash inputs for cattle raising, 1969

Feed oats*	$350
Fencing repairs	230
Seed oats, millet, lucerne	260
Drenches, vaccines	106
Veterinary expenses	190
Baling contractor	470
Fertiliser	410
Fuel and oil	300
Trace-element sprays	30
Contract planting of oats	100
Electricity (¾ of total)	450

*The price of feed grains varies greatly. One year later the price of oats had risen from 1·5–2 cents per kilogram to over 4 cents.

Two items in table 6.9 highlight one of the problems of feedlots: because the animals are close together in a small paddock they are subject to the spread of diseases and parasites. All the cattle are sprayed twice yearly (using the orchard spray cart) against fleas and lice. On the credit side, however, the animals are always under the eye of the farmer, so that any sick animal is quickly noticed and treated. For the same reason practically no calves are lost at birth.

Labour is the other input that is tremendously high. Look again at the work plan in table 6.7. Which claims more time—orchard or cattle? Which has a slack period? (Remember that the last column applies to every day of the year, including weekends.)

You can see how hard and continuously Mr and Mrs Hamden have to work to get through all these tasks. If they employed labour they would have to pay so much for overtime and week-end work that the whole farm would be uneconomic. So much also depends on personal attention to the animals and the regular task of cutting feed that it is hard to get anyone to do the work, even for a few days.

You will have noticed how this farm has gone through many stages of development, at every stage becoming more productive through the application of increased knowledge and improved techniques. Before the turn of the century, the farm was part of the squatter's run of a man named Dew, who let his animals graze practically as they wished. His cash inputs and labour inputs were extremely low, and so was his return per hectare. Then came the wheat stage, the furrow-irrigated orchard, the spray-irrigated orchard and now the feedlot programme.

Go back over this study and set out in a table the conditions that made each new stage necessary or desirable, the knowledge and techniques that made it possible, and the added inputs that were needed. Note also how many of these advances brought new problems for which science had to find solutions.

Mr Hamden has certainly used science to make his farm more productive; but he has done more than this—he has used the best advice of the universities and the Department of Agriculture in a much broader sense. Notice in the photographs the Mallee scrub that has been left and the fine windbreaks planted (figure 6.18). These not only reduce the drying and damaging effects of the wind, but add to the beauty of the farm and provide a home for a wide variety of birds, which keep the insect pests in check. No insecticide sprays are used on the fruit (only arsenic for codling moth in the apples), because these sprays (like DDT) would kill the birds, enter the soil, affect the cattle, and harm the people who eat the fruit and meat produced. The growth of lucerne in the orchard and the spreading of manure keep the soil fertile and in good condition, so that the orange trees are healthy and only need a trace-element spray. All these things save money and time, but they also ensure that soil, plants, insects, animals and birds all work together in balance as they do in nature. This is a good example of the ability of conservation to go hand in hand with high production if the farmer loves his land and his animals and the quality of the life he leads.

Draw diagrams to show the farming system when the first settlers used the land and the changes in the system that the present owners have made. Have they made the land more productive? How? Is it in a 'better state'? In what ways?

7

Farming in east Gippsland

Gippsland is an area of rich farmland extending from about 80 kilometres east of Melbourne through to the coast at Lakes Entrance, and encompassing the land between the Great Dividing Range at its northern limits and the sea to the south. We are going to consider the farmlands along the banks of the Latrobe River (figures 7.1, 7.2 and 7.3).

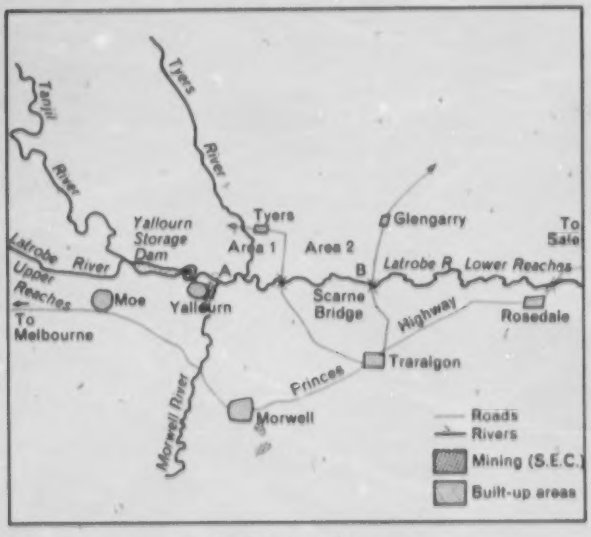


Figure 7.1: Location map

As the nineteenth-century pioneers moved out from Melbourne they discovered that the land was fertile in the river valleys. However, when the first settlers came to the Latrobe River they were very careful to build their houses on higher land away from the stream, and during the winter and spring they would not use the flat land down by the river. (What problems are suggested by the description 'flat land down by the river'?) This was the case until the early 1950s, when the State Rivers and Water Supply Commission decided to do something to prevent the annual serious flooding.

With this end in view, the Latrobe River Improvement Trust (L.R.I.T.) was formed, a step that was to benefit greatly the farmers who held land along the river. It was decided that as well as undertaking flood prevention measures, the L.R.I.T. would enable irrigation water to be drawn from the Latrobe River for use during summer, and for cultivation of crops with high water requirements. It is usual to make use of a river in this fashion when trying to control its flow. In addition, hydroelectricity is sometimes generated if a dam is built to control the flow.

Figure 7.2: The floodplain of the Latrobe River at Rosedale

Figure 7.3: Farming along the Latrobe River at the Scarne bridge

There is no planned irrigation system along the Latrobe River, but farmers on properties with river frontages can pump water from the river for irrigation of adjacent paddocks. Later in this study we shall see how much land they irrigate, and the main crops grown under irrigation.

Until 1949, rivers and drainage in Victoria were under the control of the Public Works Department, but during that year the state government realised that more powers were needed to control a whole river system—that it was useless to expect different town councils and shire councils along the river to be able to make a coordinated, effective attack on the problems. Thus the River Improvement Act was passed, by which the State Rivers and Water Supply Commission was to have control over all streams and rivers in Victoria. The first problem to be tackled was the King River, draining north from the Mt Buller area, and the second was the Latrobe River.

In order to make the river flow at a more constant speed it was first 'de-snagged'. This means that it was cleared of debris such as fallen trees and branches, and refuse that people had dumped. Then some of the bends were straightened out and excessive silting removed where this was causing the river flow to slow down. In other words, the river was given an unimpeded passage. Some of the tributaries were also dealt with, especially Eaglehawk Creek, Flynn's Creek and the Tyers River. Erosion along the banks of many of the tributaries, and of the Latrobe itself, was very bad in some areas and this was causing the river to become choked with the eroded material. The S.R.W.S.C. began an anti-erosion campaign and arrested the existing deterioration.

If you look at figure 7.1, you will see that the main dairying area along the Latrobe lies between the confluence of the Latrobe and Morwell Rivers and where Princes Highway crosses the Latrobe at Rosedale. Downstream from this point, the floodplain is used generally for beef cattle and fat lamb grazing, with the beginnings of intensive cropping of oats, millet and maize.

The dairying area along the Latrobe floodplain can be divided into two sections, according to the degree of flood protection afforded by the works of the L.R.I.T. and also in relation to the comparative natural drainage conditions (figure 7.4). Area 1 runs downstream from the confluence of the Morwell and Latrobe Rivers to the Tyers–Traralgon road bridge; area 2, from the Tyers–Traralgon road bridge downstream to the Scarne bridge, or the vicinity of the confluence of Eaglehawk Creek and the Latrobe. Area 1 enjoys a reasonably high degree of flood protection, whereas area 2 has only moderate protection, and these conditions are reflected in the rating variations applied by the L.R.I.T. Both areas, however, have enjoyed much-improved flood protection since the formation of the L.R.I.T.

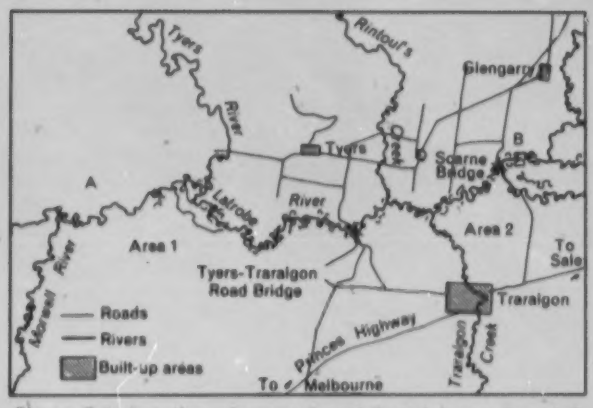


Figure 7.4: Location of areas 1 and 2 and farms A and B

Various farmers were asked about conditions along the river, and all agreed that there had been improvement since the early 1950s. Farmer A recorded that before the improvements were carried out water lay on 8 to 12 hectares of his land for three to four days, but now only 6 hectares are subject to flooding and the water only lies there for a maximum of two days. From the map you can see that this farm is at the upstream end of area 1, and would be less subject to flooding than farms lower down the river.

Compare his statement with the case of farmer B in area 2 downstream, who used to expect at least 20 hectares to be flooded and the water to lie up to two months. The same area is still subject to flooding, but now the water only lies two days; as well, only 2 hectares of his paddocks are permanently waterlogged, compared with 6 hectares previously.

Table 7.1: Comparison of farm A and farm B

	Farm A	Farm B
Area on floodplain	37 ha	57 ha
Area subject to flooding prior to 1950	12 ha	20–57 ha
Area subject to flooding since 1950	6 ha	20 ha
Duration of floodwaters prior to 1950	4 days	2 months
Duration of floodwaters since 1950	2 days	2 days
Permanently waterlogged area prior to 1950	nil	6 ha
Permanently waterlogged area since 1950	nil	2 ha
Work carried out on the floodplain to assist drainage	Two river cuts and two flood cuts	Floodgate (by L.R.I.T.) and drainage cuts (privately constructed)
Stock carried on floodplain prior to 1950	60–70	70–80
Stock carried on floodplain since 1950	90–100	100–110

Apart from reducing the inconvenience to the farmer when floods occur, what do the improvements mean? How can they affect the farmer in his planning of the year's work? What do they mean financially to him? Table 7.1 compares farm A and farm B. Study carefully the data given and then answer the following questions.

What are the major benefits that both farmers have gained since the formation of the L.R.I.T.?

Farm B has received an additional improvement from the L.R.I.T. What is it?

As well as the difference in the areas of the properties lying on the floodplain, there are other major differences between the two farms. Looking at figures 7.1 and 7.4, decide which would be the better proposition if you had the chance to purchase either. Give reasons for your choice.

Farm A

This property is at the westernmost (upstream) end of the L.R.I.T. area and thus is less subject to flooding than farm B. However, in the very severe 1934 flood, huge sand deposits were left over part of this area, mainly on the river banks.

The sand and silt came from State Electricity Commission (S.E.C.) overburden dumps upstream (figure 7.5). In parts the deposit was 4 to 6 metres thick, forming levees along the river banks as well as being spread over the land. This was the worst flood recorded—20 hectares of the farm was inundated.

Farm A was one of the first properties to gain protection and benefits from the activities of the L.R.I.T. Soon after its formation the Trust constructed two river cuts and two maximum flood cuts on the farm (figure 7.6). These do not prevent flooding, but they do help the floodwaters drain back into the river at a very much faster rate (see table 7.1). Actual regulation of the river flow has been helped by the construction of an S.E.C. weir and by the Yallourn Storage Dam completed in 1963 (figure 7.1).

Farmer A's use of the floodplain has not changed greatly since these improvements were introduced, but this is mainly due to the fact that the property has higher ground that he can utilise in times of flood. For him, the main advantage is that the farm can now carry greater numbers of stock, and therefore his percentage return per hectare is higher. The floodplain is used only for the grazing of cattle and not for crops. Although much of it is very fertile land the farmer considers it too risky to plant crops in this area, even now when the flood problem is very much reduced.

The floodplain is sown to permanent pasture with rye and clover. During summer, when there is often no rain for three to four months, irrigation is used to keep the permanent pasture green and lush so that the dairy herd can graze there all year round. Dairying is the main concern of this farmer. His herd consists of 90 to 100 Jerseys and Friesians (figure 7.7).

The irrigation is of the spray type. The method used is to start with heavy watering in November for about twelve days, giving the equivalent of 75 millimetres of rain; then, up until February, the floodplain is irrigated every two weeks at a lesser rate. At the same time it is fertilised with superpotash in the ratio 7:1 (seven bags of superpotash to one hectare of pasture). This treatment provides excellent feed for the dairy herd all over the floodplain portion of the farm, except for one area a little away from the river, which has grey porous soil that is inclined to become boggy under irrigation and then is likely to be cut up by the cattle's hooves.

Before the L.R.I.T. improvements were made, the dairy herd had to be moved to higher ground away from the river during times of flood. It was essential for farmers in this whole area to have land away from the river that could be used in these emergencies. Farmer A has approximately 24 hectares of 'hill country' that he used for this purpose; on this land he runs a herd of about 95 Herefords, with a few Black Polls, that he keeps for beef production, mainly veal. (Do you know what veal is? If not, find out which animal produces veal and under what circumstances.)

The hill country is also used for the dairy herd in the calving season and in the early spring when they are 'dried off'. What do you think this term means? While the dairy herd are on the higher ground, the beef cattle and vealers are often put to graze on the floodplain, which is particularly lush at this time of year. Can you think of any reason why the pasture on the floodplain should be so good at this time? There are no crops grown on any part of the property, but 8 hectares are sown for hay. Why does the farmer need to have hay?

Table 7.2 was prepared from two sample holdings having both floodplain and higher sections in the general vicinity of farm A. The combined area of floodplain land on the holdings is 80 hectares, and the records showed that the floodplain sections accounted for their share of the overall production increase. (What proportion of the total do you think their share might reasonably be?)

Table 7.2: Production increase from selected holdings in area of farm A*

Farm	Production of butterfat, 1949–52 (kilograms)	Production of butterfat, 1962–65 (kilograms)	Increase (kilograms)	Other stock carried
1	24 555	35 828	11 273	20
2	27 095	28 766	1 671	50
Total	51 650	64 594	12 944	70

*Statistics averaged over three-year period to eliminate fluctuations due to individual seasonal conditions

Figure 7.5: S.E.C. overburden dumps with some reafforestation

Figure 7.6: A drainage cut in the floodplain, with drainage gate in the middle distance

Figure 7.7: Jersey cow grazing on river flats

The price of butterfat at the time these figures were recorded averaged about 88 cents per kilogram and other stock were returning a profit of $30 per head. Work out the dollar value of total productivity increase, and also the increase per hectare of floodplain land.

Farm B

Farm B is also concerned mainly with dairying, and the owner has a city milk contract. The property has an area of 57 hectares, with 27 hectares adjacent to the river. Even today the whole 57 hectares can be flooded in a bad year, but generally only 20 hectares are regularly flooded. The significant factor again is the speed with which the water now drains away, partly due to the floodgate that the L.R.I.T. has installed and partly the result of the privately constructed drainage channels.

The property now carries some 104 dairy cattle —Jerseys and Friesians—which are able to graze on the floodplain for at least ten months of the year (figure 7.8). There are only about one or two weeks when the floodplain cannot be used because of actual flooding, but the whole area is used in strict rotation with the upland pasture. All the higher ground is sown to permanent pasture, and slowly the floodplain is being put under permanent pasture.

The usual way to develop the floodplain is to clear the original vegetation, which here consists of ti-tree up to 12 metres high and tough tussocky grass, and then plant oats, millet and rape. These crops have two uses; the beef herd of about 40 Herefords can graze on them, and they can be harvested and used for winter fodder; if the floods come and the crop is ruined for harvesting, it still has some value as grazing land. The next season a summer crop is planted of either rape or millet, with the same uses, and the third year permanent pasture is sown, using a mixture of rye and clover. Eventually all the farm will be under permanent pasture and provision will have to be made for a certain number of hectares to be set aside for fodder crops.

The carrying capacity of the floodplain is increasing as the land is improved. It is now suitable for grazing practically all year round, whereas previously it could only be used for two or three months. Before improvement, in addition to the limitations on the period of use, the cattle had to be constantly moved, either to better pasture or out of the way of the floods. Farmer B recalls that in 1952 he had to move the cattle nine times, which was not only irksome, but also a waste of manpower, time and therefore money. He agrees with many of his neighbours that, for small properties in this area, the most profitable farming is dairy-

ing, as long as there is sufficient elevated land to hold the dairy herd in times of flood. The most risky farming here is crop growing, and the least risky, but not so profitable, is beef production.

Write a short essay, imagining that you are either farmer A or farmer B and you are writing to another farmer about how you are going to plan your activities on the property for the next few years, taking into consideration that you have to make money in order to live but that floods, drought and other events can happen. Make your essay as realistic as you possibly can.

Table 7.3 is similar to table 7.2, but deals with four sample holdings at the eastern end of the area we are considering.

Table 7.3: Production increase from selected holdings in area of farm B*

Farm	Butterfat production, 1953–56 (kilograms)	Butterfat production, 1962–65 (kilograms)	Variation (kilograms)
1	14 868	19 515	+ 4 647
2	11 842	11 257	— 585
3	10 262	14 563	+ 4 301
4	14 129	16 802	+ 2 673
Total	51 101	62 137	+ 11 036

*Statistics averaged over three-year period to eliminate fluctuations due to individual seasonal conditions

Assuming butterfat prices to be the same as before and that the floodplain holding on these farms totals 110 hectares, the overall increase per hectare in this area is in the region of $88.00. How does this compare with the figure that you calculated for the other end of the area under discussion? Can you think of any reasons for this difference?

Figure 7.8: Mixed herd of dairy cattle grazing on river flats. Identify the different types

Figure 7.9: Dairy processing factory outside Traralgon—the destination of the dairy farm's output

8

Food production in South America

Up to this point you have been looking at how food is produced in Australia, some of the difficulties associated with different types of food production, and the ways farmers attempt to solve these difficulties.

In other parts of the world, agriculture sometimes resembles and sometimes differs from farming in Australia, as you have seen in Levels One and Two. In this book, think more carefully about how the various elements of the farming system differ from one country to another, and what may cause these differences.

Figure 8.1: The countries of South America

South America is a varied continent. The home of early Indian civilisations such as the mountain-dwelling Incas of Peru, the continent has some spectacular archaeological ruins, reminders of the might of these great builders. The sixteenth century, however, saw the arrival of the Spanish *conquistadores* (conquerors) under daring, ambitious and ruthless leaders like Pizarro. The Indian culture was virtually annihilated and a powerful colonial empire took its place. Centred in Lima, the Spanish set out to convert the 'heathen' and to tap the continent's rich mineral resources, especially gold. Roman Catholicism became the compulsory religion, and Spanish the official

Figure 8.2: The Roman Catholic Church of Saint Francis of Assisi at Minas Gerais, Brazil. Note the Portuguese influence in architecture and religion. ***(Secretary of State for Foreign Relations, Brazil)***

WESTERN MOUNTAINS

X Andes
Extend 6500 kilometres N-S and only 300-650 kilometres E-W. Formed by folding and faulting; recent movement, therefore many volcanoes and earthquakes (e.g. Peru, 1970). Many peaks over 6000 m. Glaciated in south, with fiords on coast. In north, ranges run NW-SE with intermontane basins. High plateau in southern Peru and Bolivia.

Y Western Plains and Basins
Coastal plains in north; narrow trough in Chile.

Z Coastal Range
Important in Chile.

EASTERN HIGHLANDS

P Guiana Highlands
Resistant sandstone forms flat-topped hills.

Q Brazilian Highlands
Hard volcanic layers form ledges. Steep scarp on east.

R Patagonian Plateau
An unbroken plateau

LOWLANDS

A *Llanos* of Orinoco
Wide river valley and undulating alluvial plain.

B Amazon Basin
Flat floodplain composed of sand, gravel, silt. Complex river system drains Andes and Highlands. Mouth is submerged to form a delta.

C Gran Chaco
The lowlands of the Parana and Paraguay Rivers. Flat and swampy in north. Many rivers intermittent.

D Pampas of Argentina
Old rocks covered by silt and loess (wind-borne deposits) from west. Porous, with underground drainage.

Figure 8.3: Important structural features

Climatic Characteristics

- hot, wet and humid all year
- hot all year; wet and dry season
- hot wet summer; mild winter; no dry season
- hot dry summer; warm wet winter
- warm summer; cold winter; wet all year
- little or no rain
- temperatures drop 3–4°C with every 500

Ocean currents

- Warm equatorial currents—heat east coasts, making them warmer than west coasts.
- Cool currents—make west coasts cooler and cause offshore fogs; influence coastal Peru and Chile.

Air masses

- Wet, tropical air masses-bring rain to north and east all the year, and to the centre of the continent in summer (January)
- Polar air—blows over the southern areas in summer and to the centre of the continent in winter; after crossing Andes is dry

Figure 8.4: Climatic areas and influences

language. The only area not settled by Spain was Brazil, which was colonised by Portugal. With the nineteenth century came a series of wars to free the continent from its colonial overlords and, under nationalistic leaders like Simon Bolivar, most countries won their independence between 1811 and 1825. The area is still, however, one of political instability. Although there are some democracies many countries are under military control, and governments tend to be rather short-lived. (What are some South American countries that have recently featured in news reports?)

Thus the continent has a wide range of peoples with varied cultural backgrounds. What about the land surface? Compare figure 8.3 with the relief map in your atlas and name the rivers marked. Are there any other important rivers that should have

Forests

Equatorial—*Selvas*
Dense evergreen rainforest with no seasonal change and luxuriant growth. High canopy with tiers and vines below. Dense ground cover near clearings.

Tropical and subtropical
Seasonal changes, so some trees are deciduous. Trees lower, with some grassy areas.

Mediterranean scrub forest
Scattered evergreen trees, drought resistant. (Eucalypts introduced.)

Cool temperate forest
Dense forest because of wet conditions. Mixed forests of beech, cedar, etc. Evergreen in south.

Arid areas

Drought-resistant (xerophytic) plants. Atacama desert of northern and Peru.

Mountains

Vegetation varies with altitude. Many trees introduced.

Grasslands

Tropical savannahs
Hot grasslands with scattered trees and seasonal growth.
(a) *Llanos* of Venezuela. Sharp contrast between green and brown seasons.
(b) *Campos* of eastern Brazil. Trees are drought resistant.
(c) *Chaco*. Continental climate; trees are deciduous.

Temperate grasslands
Pampas of Argentina. Rich grasslands—mild climate and good soil. Winds and porous soils retard tree growth, but Indian burning may have removed trees.

Semi-arid grassland
Tussocky grass and scrub in Patagonia—rainfall erratic

been marked? Figure 8.3 provides a summary of the relief and geology—in other words, a very brief description that must be used carefully. It gives you some idea of what the land is like.

Figure 8.4, similarly, provides a brief description of the climate, and figure 8.5 describes the natural vegetation before man changed it.

Farming in the Andes

To reach the village of Pisac high in the Andes of south-east Peru would have been a hazardous journey for the early Spaniards, or for the Indians who have inhabited the area for thousands of years. Not so today. It simply entails a spectacular two-hour flight from Lima to Cuzco, the capital of Cuzco Department (Province), and from there a road trip of less than 30 kilometres.

The aircraft flies over some of the world's most awe-inspiring scenery, as we pass range after range of the Andes (figure 8.6). So high are these mountains that some peaks right on the Equator, in Ecuador, are snowcapped all year round. In southern Peru we are still well within the tropics, and yet many mountain areas are snow-covered, rising above the 5800 metre snowline.

Figure 8.6: The Andes in southern Peru

Formed by massive folding in recent geological times, the Andes consist of a series of folds, or ranges, running roughly north-west to south-east (see figure 8.7). Between these ranges are intermontane basins and valleys. Rivers drain to the Pacific, or plunge through spectacular gorges to the lowlands of the east, and thence to the Atlantic. Because the earth movements that formed the Andes were fairly recent, the area is still very unstable. Most of the great peaks are volcanic and many are still active. Earthquakes are common; the Peruvian earthquake of 1970, which caused the loss of over 80 000 lives, was simply one of the more recent of a series of similar disasters. In 1950, for

◀ *Figure 8.5 (left): Natural vegetation*

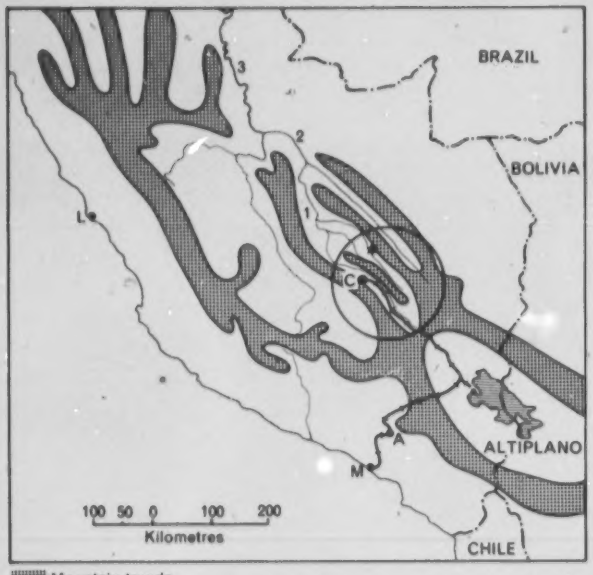
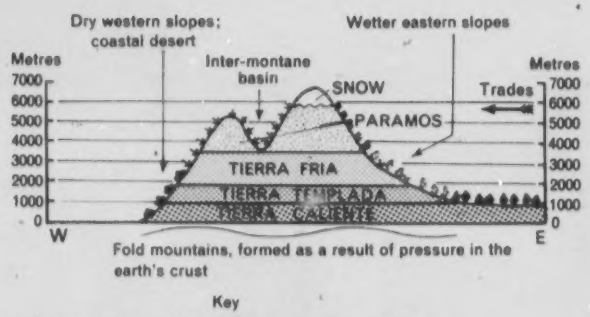


Figure 8.7: The structure of southern Peru



Key

- Tropical *selvas* (dense forest) and savannah grasses.
- Lower, temperate forests and scrub in eastern *montana* and slopes.
- Well-watered grasslands on eastern slopes in Paramos zone.
- Tufted grasses and drought-resistant scrub (*puna*) in west and basins.
- Desert xerophytic vegetation in west near coast.

Figure 8.8: Changes of climate and vegetation in the Andes

example, much of Cuzco was destroyed by an earthquake, and the nearby Andean countries have also suffered their share of devastation.

As we approach Cuzco by air over these great mountains, we look down on a large basin like a high-rimmed saucer. Cuzco, with its uniform, tiled roofs, seems to match the surrounding brown hill-slopes. It is perhaps surprising that most of the mountains are dry and bare. Too far north to receive rain from the westerly winds, any rain has to come to the area from the South-east Trades, and these have already crossed the vast plains and shields to the east (see figure 8.8). The rainfall on the eastern slopes is, nevertheless, still higher than on the west, and comes largely in summer, from October to April (see table 8.1). So dry are the basins, protected from both east and west, that the Indians, whose empire was centred in this area, had to use irrigation to grow their crops.

As we leave the artificial atmosphere of the aircraft, a number of physical changes become apparent. Although at only 12° south latitude, we are now nearly 3250 metres above sea level and the temperature is very different from that in Lima, our takeoff point. On average, in dry conditions, temperature can drop 3–4°C for every 500 metres of altitude. Using figures 8.4 and 8.8, work out which climatic zones the aeroplane has flown across.

The other noticeable change is that, with any exertion, we will become very short of breath. This is because the air is so much rarer, or thinner, at such a high altitude. The local Indian, with his short, stocky body and great lung capacity, can endure these conditions—he has become physically adjusted, over the many centuries, to living at this altitude. But for the traveller it is a different matter, and 'altitude sickness' is a common problem. The thinness of the air also means that there is less atmospheric hindrance to the sun's rays. In sunlit areas it may be quite hot, but the temperature drops quickly in the shade. In the same way there is a great difference between temperatures during day and night (see graphs comparing diurnal temperature range at Cuzco and Mollendo, figure 8.9). Although Cuzco has a large diurnal range, there is only a small seasonal difference, as we are still within the tropics (see table 8.1).

Now refer to figures 8.4, 8.5 and 8.8 and write a short paragraph to show how vegetation changes between Lima on the coast and Cuzco.

Cuzco, today the focal point of south-east Peru, was once the capital of the Inca Empire. At its height, from about the eighth to the twelfth century A.D., this empire, ruled by an *inca* (king), covered over two million square kilometres and governed about six million people. Great builders, craftsmen

Table 8.1: Climate of Cuzco (3225 m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Temperature (°C)	13·3	13·9	13·9	12·8	11·1	10·6	10·0	11·1	12·8	13·9	14·4	13·9	—
Rainfall (mm)	163	150	109	51	15	5	5	10	25	66	76	137	812

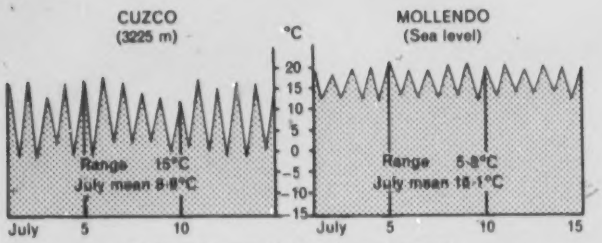


Figure 8.9: The diurnal temperature ranges of Cuzco (3225 m) and Mollendo (sea level). The two graphs show the effect of altitude on diurnal range. Temperatures are shown along the vertical axis, and the days of the first half of July along the horizontal axis

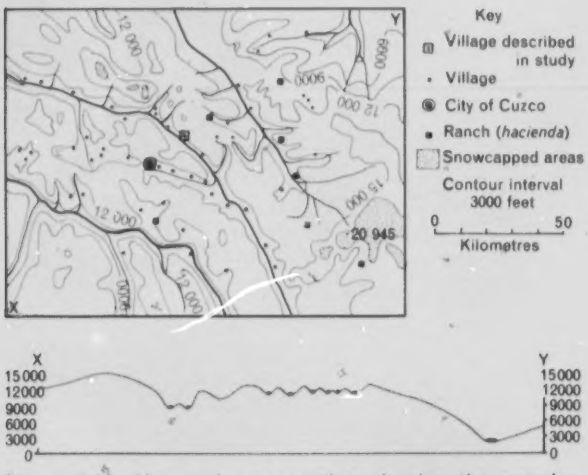


Figure 8.10: Map and cross-section showing the complex pattern of ridges and valleys in the Andes near Cuzco. To the north-east there is a marked drop, leading to the lowlands of the Amazon Basin. Note the position of Cuzco at the head of a valley, the number of small villages and their locations, and the number and locations of ***haciendas*** *in the area*

and organisers, the Incas lived communally. There was no money and no profit: one-third of the produce went to the producer, one-third to the state, and one-third to God, sun worship being the basis of the religion. Unfortunately, most of the great Inca buildings were completely destroyed when the empire was conquered by Pizarro in 1533. However, a huge fort above Cuzco, and such ruins as Machu-Picchu, give some indication of the Incas' achievements. Machu-Picchu, the famous 'lost city of the Incas', was never discovered by the Spaniards because of its incredible position above a gorge (figures 8.11 and 8.12). As evidence of their engineering and architectural skill, Inca builders were able to lay huge blocks of stone in such a way that the constructions resisted earthquakes; after the Cuzco earthquake of 1950, a number of old Inca buildings were found intact beneath the fallen Spanish dwellings.

Today Cuzco has a population of 80 000, mostly pure Indian or *mestizo*, of mixed Indian and European descent. The city attracts two types of 'visitors'. On the one hand there are the tourists, who come in their thousands to see the fascinating old Indian-Spanish city with its many churches, palaces and plazas, and to travel to the impressive ruins nearby, notably Machu-Picchu. Then there are the many Indians from the surrounding areas who arrive weekly for the Saturday market, to barter their foodstuffs among themselves and to sell their craftwork to the ever-willing tourists.

Some Indians may have travelled, probably on foot, the 26 kilometres from the village of Pisac, to which we are heading. Our method of travel is easier, although the road is hardly first class. Passing a few farms and tiny villages we rise to over 3600 metres and eventually, at a turn in the road, we look down on Pisac and the spectacular valley of the Vilcanota River, the headwaters of the Urabamba. Should we follow this river downstream we would go through a massive gorge past Machu-Picchu, reach the junction with the Ucayali River, and eventually, at Iquitos in eastern Peru, join up with the Amazon, flowing to the Atlantic. Here, high in the Andes, we are on the watershed of the mighty Amazon River.

Refer to figure 8.13. Draw a sketch transect across the valley and mark in vegetation changes, settlement, the position of the river and the area of cultivation. What are terraced hill slopes? Can you identify any evidence of this practice in the photograph? Why is it necessary to use such a method of cultivation?

Examine figure 8.14. What factors limiting food production can you see in this photograph?

Pisac is one of many isolated, self-sufficient Indian villages throughout the central Andes. Some of its inhabitants have possibly not even travelled as far as Cuzco. The valley has probably been the site of settlement since long before Inca times; in terms of permanence, then, it contrasts markedly with the shifting Indian settlements of the Amazon Basin. The village is run by an *alcalde* or mayor, who is subordinate to the district governor and is elected by the elders of the community. Large family groups form the backbone of a closed community that is suspicious of any outsider.

As was the custom in Inca times, some of the agricultural land is still held communally. In much the same way as 'strip farming' was organised in Europe before the agricultural revolution, each family is allocated plots in various areas every year. (Why do you think the allocation of plots is deliberately changed?) The system of communal control is, however, being broken down as individual owners take over the plots, partly because of increased competition for land, and partly

because of the introduction of cash farming. Nevertheless, the average farm size is only about 0·8 hectare. In order to meet the needs of a growing population, many of the communally held pasture lands are now being used for crop cultivation.

There is seldom much food surplus for sale. Most food grown is used by the 'family', and the farming is therefore largely subsistence. Potatoes and maize (corn) are the original Indian crops, but wheat, barley and some vegetables have been introduced. Farming techniques are very simple; there is little money for machines, or for fodder for draught animals, although some oxen are occasionally used for ploughing and threshing. Irrigation is on a small scale, ditches being dug by hand. Rotation of crops is common: on the flat areas the cycle is usually one year of potatoes, one of barley, and three of fallow; the hillsides are planted with potatoes for a year and are then used for pasture for five to ten years.

To overcome the lack of machinery, a system of exchanged labour called the *aine* system is used. At planting time, for example, people form work parties to prepare one another's land. Two people might dig the soil and a third, probably a woman or boy, will turn the sods to right and left to form the furrows. To sow the crop the first person makes a hole with a digging stick, the second plants, and the third spreads fertiliser. There is, however, a growing inequality of farm sizes, and the system of exchanged labour is breaking down because the larger landowners prefer to pay for labour. Therefore the transfer of communal plots to individual owners, and the breakdown of the *aine* system, are both altering the community structure of the village, and may result in the emergence of groups of small landowners and labourers.

The pasture lands, known as *ejidos*, are still partly communal and are used for grazing llama, alpaca and sheep. Alpaca and the wild vicunya, both of which are small members of the llama family, provide wool. This may be spun and woven locally, or sent by train to the commercial market at Arequipa (see figure 8.7). The llama, resembling a small camel, is very important to the Indian as a pack animal. Although it stands only about 140 centimetres high, it can carry up to 45 kilograms weight and can go for days without food or water. As well, its flesh is edible and it yields a coarse wool.

Not all of the villagers have plots of land to farm for themselves. Many have to work as labourers on the local *haciendas*—big farming estates or ranches like the *estancias* of Argentina. In early colonial times large grants of land were made, and inequality of land ownership has remained to the present day: 82 per cent of the land in Peru is owned by 0·8 per cent of the landowners. The *hacienda* is fairly self-sufficient, but has some surplus produce for sale. Farming techniques are still simple, and goods are sold locally because of the difficulty of transport. A worker is under contract to the *haciendado* (owner or manager) and may receive 'favours' instead of wages. For example, he may be given a plot of land to grow his own food, or he may receive medical aid. The *haciendas* draw their workforce from the unemployed of the villages. These villagers may farm as tenants on the *haciendas*, but usually they become virtual serfs or slaves on a feudal type of estate.

The villagers earn a little money from various crafts. What might these be? (Remember the people's cultural inheritance and the raw materials they have to work with. Note also that tourism is important in Peru; each year the country receives many visitors from the United States.)

The market, held each Sunday morning, is an important part of village life (figure 8.15). Its main function is the exchange of goods among the local people, primarily different grain crops, vegetables, coca (the dried leaves of a shrub, chewed for their stimulant properties), or simple household items. Sales to tourists are an important addition to a small income. The market has, however, another important function: it is a meeting place where people from many villages can get together. Although physically similar, with their short, broad bodies, brownish skins and Oriental features, the people from the various villages are differentiated by their clothes, especially their hats. Pisac villagers naturally predominate, the women in red skirts and flat, round, red hats, and the men in brown jackets, kneelength trousers and multicoloured knitted caps. Despite the low temperatures, both men and women go without shoes or wear rough sandals. Most will be speaking Quechua, the Inca language, for these people are Quechua Indians, the descendants of the Incas. Those few Indians who can speak Spanish, the official language, wear high white panama hats to signify the fact.

The central Amazon

Let us now continue our journey from Pisac, high in the Andes, down the rivers until we join the Amazon. For many hundreds of kilometres we are still in Peru. Descending swiftly from the mountains through canyons and gorges, we reach the *montana*, the tropical lowlands east of the Andes, accounting for half the area of Peru. It is here that the Amazon River begins, drawing its waters from the many small rivers that flow down from the Andes.

Figure 8.11: Machu-Picchu

Figure 8.12: The gorge at Machu-Picchu

Figure 8.13: View over Pisac and the Vilcanota River

Figure 8.14: The Vilcanota Valley downstream from Pisac

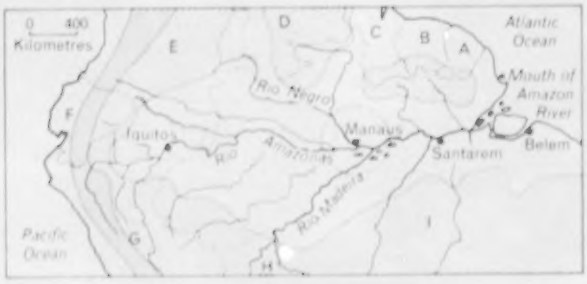
Figure 8.15: Market day at Pisac

Figure 8.16: Street scene, Pisac

Fig. 3.3.17. The Amazon—how can you tell that the river is a vital part of the way of life of the people who live in the hut in the centre of this photograph? **(Secretary of State for Foreign Relations, Brazil)**

Fig. 3.3.18. Part of a 'floating city' on the Amazon. How can you tell from the photograph that the river is far more important than the land area for these inhabitants?

Figure 8.19: Along the banks of the Amazon. Describe the vegetation you can see in this photograph. What is an epiphyte? ***(Secretary of State for Foreign Relations, Brazil)***



Key

- Amazon Basin—most areas less than 150 m above sea level
- Shields and lower mountain regions
- Andes
- Western coastal areas
- Swamps
- Major rivers
- International boundaries
- Major cities on the Amazon
- The area discussed in detail

Countries

A. French Guiana
B. Surinam
C. Guyana
D. Venezuela
E. Colombia
F. Ecuador
G. Peru
H. Bolivia
I. Brazil

Figure 8.20: The Amazon Basin

The forest of this basin is as dense as anything to be found in Brazil, and Iquitos, Peru's Amazon city, is as colourfully tropical. With a population of 100 000, nearly all Indian, Iquitos provides the world with such exotic products as orchids, jungle birds and animals, rosewood for perfume, and *leche caspi*, from which chewing gum is made. Only accessible by air or water, Iquitos is the most inland port in the world—ships bring cargo direct from London. (From figure 8.20, work out how far upstream such a ship would travel.) With its own 'little Venice', or floating city, Iquitos is a strange, remote, slow-moving place.

Even at this point, not far from its source, the Amazon is over 1·5 kilometres wide. From here it will take the water more than three months to reach the mouth of the river at Belem. By this time the Amazon will be about 80 kilometres wide, and will have flowed almost 6500 kilometres. Many of its thousand or more tributaries, like the Negro and the Madeira, are great rivers in their own right. They contribute to the enormous load, twelve times that of the Mississippi, which the Amazon pours far out into the Atlantic Ocean. This mighty river system serves and drains vast areas of Brazil and Peru. Refer to figure 8.20—what other countries does it influence?

The Amazon and its tributaries drain the vast Amazon Basin, which covers an area almost as large as Australia. Most of this enormous lowland is less than 150 metres above sea level, and from Iquitos the river only drops 120 metres in over 3200 kilometres to its mouth. The Amazon therefore flows, for most of its course, through silt-covered, swampy floodplains, and has many braided (multiple) courses and natural levee banks. Parallel to the various rivers are lakes, swamps and secondary drainage channels (see figure 8.21).

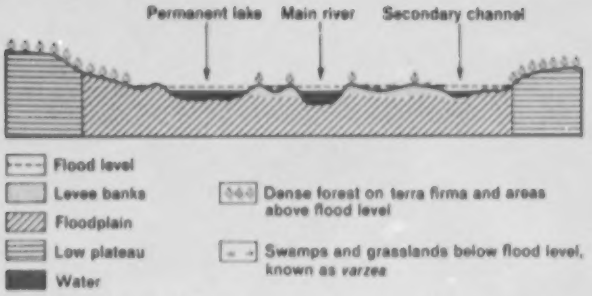


Figure 8.21: Section across the Amazon floodplain

The Amazon Basin has always had an aura of dark mystery and hidden dangers. The murky waters of the rivers hide many perils, notably alligators, and their banks and the surrounding forest are virtually impenetrable. On either side of the Amazon the jungle seems indistinguishable from the dark, green-black water.

This is one of the densest rainforests in the world. Growth in these *selvas*, or equatorial forests, is luxuriant. The tall, broad-leafed, evergreen trees form a canopy 60 metres above the ground, while tiers of smaller trees and vines compete for light in the gloom below. Only on the edges of clearings or rivers, where the sunlight reaches the ground, is there a dense, low, jungle vegetation. Over 4000 different species of trees are found here, valuable hardwoods on the higher areas and softwoods on the floodplains. Trees bear flowers and fruit at any time of the year, as there are no seasons. Where depressions or old valleys are below flood level there are swamps or grasslands called the *varzea* (see figure 8.22).

The dense forest is, of course, the result of hot, humid conditions throughout the year. The area has a truly equatorial climate, temperatures staying at about 27°C throughout the year, and annual rainfall averaging about 2000 millimetres, with the heaviest falls from December to April. Constantly high humidity (about 80 per cent) makes the atmosphere muggy and oppressive. By way of example, table 8.2 gives details of the climate of Manaus.

Most of the inhabitants of the area around Manaus are Indians, differing in many respects from those of the Andean highlands. The average population density is less than one person per square kilometre. Although some villages along the Amazon may have populations of 2000 to 3000, those inland are much smaller, often consisting

Figure 8.22: The confluence of the Rio Negro and the Amazon at Manaus (from an aeronautical chart, 1:1 000 000)

1. *How much of the area is covered with water or swamps? Why are there so many swamps and lakes? (Note topography as well as climatic influences.)*
2. *List the different river features shown on the map. Why do the rivers have such complex, braided courses? Calculate the width of the Amazon and Rio Negro at various points.*
3. *What indication do the map and the aerial photograph (figure 8.23) give of the size of various settlements in the area?*
4. *Where are the settlements located? Account for the location of Manaus and the smaller settlements.*
5. *What form of transport would these settlements use?*

simply of one large communal house. The size of the village is limited by the need to have farming plots nearby. Because of intertribal hostility, most villages are protected by high pallisades.

The 'main street' of most settlements is the river; the main traffic, dugout canoes. Each village probably has a store, and may have a school. The main buildings along the river may be brightly plastered and tiled, but the ordinary houses are of wood and thatch, supported by poles. Communal houses, in which up to 100 people from the same family group might live, are sometimes 60 metres long. Household items are few: hammocks for sleeping, wooden stools and cooking utensils, woven baskets, and clay pots. The people are skilled at pottery and basketry, but most of their crafts are associated with the production of flamboyant tribal costumes: featherwork, weaving, bark painting, and the making of small ornaments.

Most people in these small settlements are farmers, using the slash-and-burn method of cultivation. Clearing a patch in the forest is no easy task. Trees are ringbarked with a stone axe, felled, and the dead vegetation burned. The crops are then planted between the dead trees, the men preparing the land but the women doing all the other work. The most important crops are manioc (from which a flour is made), rice, cotton and beans; bananas and sugar have also been introduced. Because of the heavy rainfall the soil is badly leached, and usually after three to four years a new plot must be prepared. When possible, new plots are close to the village, which remains permanent while the farm areas are moved about it. Sometimes, however, it is necessary to move the village if all available land has been cultivated and has not recovered its fertility.

Table 8.2: Climate of Manaus (44 m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Temperature (°C)	27·2	27·2	27·2	27·2	27·2	27·2	27·8	28·3	28·3	28·9	28·3	27·8	—
Rainfall (mm)	249	231	262	221	170	84	58	38	46	107	142	203	1811

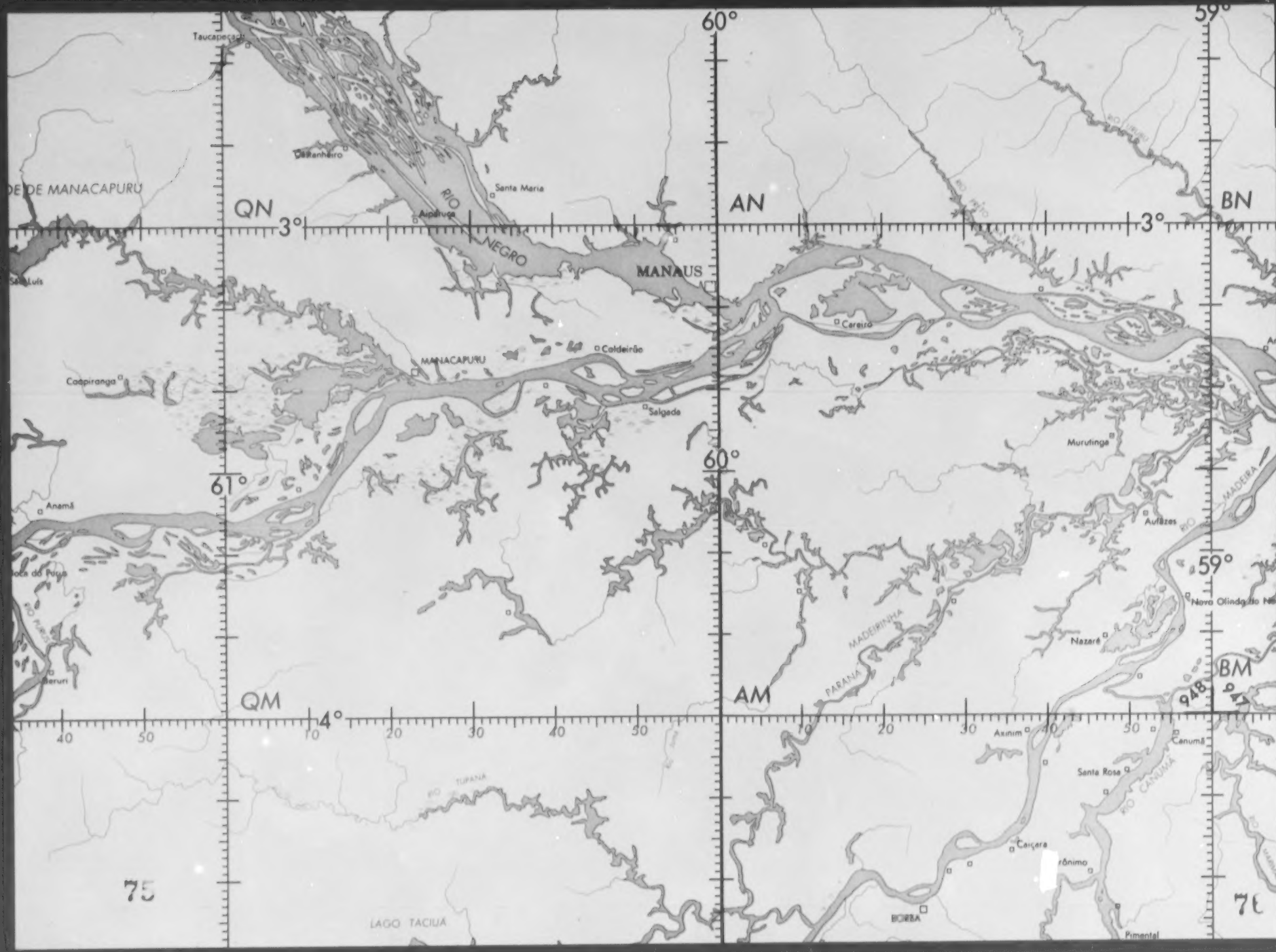

60°
59°
QN
AN
BN
3°
3°
RIO NEGRO
MANAUS
Taucapessaú
Demenheiro
Santa Maria
Aupiruçu
Careiro
Caldeirão
MANACAPURU
Coapiranga
Salgado
Murutinga
61°
60°
Anamã
Autazes
RIO MADEIRA
59°
Nazaré
MADEIRINHA
PARANA
QM
AM
BM
4°
Axinim
Canumã
Santa Rosa
RIO CANUMÃ
RIO TUPANA
Caiçara
Pimental
LAGO TACIUA
75
76
948

Figure 8.23: The city of Manaus, 1 : 40 000 (approximately)

1. *Locate this city in figure 8.20, and try to work out the approximate area of figure 8.22 covered by the photograph.*
2. *What evidence can you find that Manaus is a port?*
3. *Describe the city's street pattern.*
4. *Which is the oldest part of the city? How can you tell?*
5. *The boundary between city and forest is very clear. However, parts of the forest area have been cleared—why?*

While the women are busy working on the plots or gathering wild fruits and nuts, the men are fishing or hunting—'prestige' activities in which the tribesmen can exhibit their skill. Hunting is quite hazardous and yields little meat, but is an important part of the traditions of the people.

At the end of the nineteenth century the invention of the 'horseless carriage' created a great demand for rubber for tyres and waterproofing. There followed a rush to the Amazon, the home of the rubber plant, where for centuries the Indians had used rubber to make simple balls and ornaments. Collecting posts were set up and the collectors, mainly Indians, kept in virtual slavery. The rubber boom had its most remarkable effect on the city of Manaus (figures 8.22 and 8.23). To symbolise its new wealth this city, deep in the jungle, built a remarkable opera house and invited such celebrities as the ballerina Pavlova to perform there.

Many people made great fortunes from rubber. And then it all ended. The British, resenting the Portuguese monopoly in Brazil, smuggled rubber seed to Malaya, where rubber plantations were established and flourished. Quickly Brazil lost its importance as a rubber producer, and the downward trend has continued (see table 8.3). There have been attempts to revive the industry in South America, some by the Ford Motor Company, but none have succeeded. By early this century, the rubber boom had ended. Try to find out some of the factors that made rubber production in South America uncompetitive with the rubber industry in, say, Malaya.

Table 8.3: Rubber production of major producing areas (tonnes), 1913 and 1960

	Asia	Africa	South America	South American percentage of total
1913	51 000	18 000	45 000	39·5
1960	1 855 000	142 000	25 000	1·2

77

The Upper Orinoco rainforest, Venezuela

Many different tribes of Amerindians live in the rainforest of equatorial South America, along the banks of the Orinoco River north of the Amazon. Although they inhabit a large area, all have similar cultural backgrounds and all live by the same methods, with shifting subsistence agriculture as the basis.

Figure 8.24: The Upper Orinoco basin

Shifting subsistence agriculture is usually termed *swidden cultivation* to distinguish it from other systems of impermanent or discontinuous cultivation. Swidden cultivation may be defined as any continuing system of agriculture in which impermanent clearings are cropped for shorter periods in years than they are fallowed. In other words, areas of the forest are cleared, crops are grown in these clearings for a few years, and then they are left idle for a longer period than they were cropped. In fact, a particular area may never again be used for growing crops. In what other areas of the world that you have studied is this method used?

In the Upper Orinoco basin, the clearings being cropped are termed *conucos* and those that have been abandoned are called *rastojos*. The forest quickly invades the clearing once it is left unattended, and so the *rastojos* are all in stages of being reafforested.

The main crops grown in the *conucos* are bananas and manioc, but many other vegetables and fruits are grown in the same clearing at the same time. This practice is called *polyculture*. If the tribe has had little contact with Western or European influences, the *conucos* are polycultural; but those tribes that have been influenced by Western ideas tend to favour the one crop per clearing (*monoculture*)—usually maize. Why do you think the ideas from outside would have this effect?

One group still unaffected by white explorers, missionaries or settlers are the Waiku Indians of the Rio Ocamo. They live in longhouses occupied by many families, and continue to practise their traditional rituals. Although a Christian mission has been established there, it has not altered the Waiku Indians' elaborate culture. They practise swidden cultivation, and supplement their diet by hunting small animals, birds and fish, and gathering both wild fruits and those remaining on abandoned cultivated areas.

In 1968 there were between 150 and 200 Waiku living in one village with nine *conucos*. These had been cleared the previous December and January, and were all situated down by the river on land above the level of the heavy annual flooding. (How does the Amerindians' use of the land beside the river differ from that of farmers in the Latrobe River valley?)

After the forest has been cleared in December and January, there is a slight dry season in this area; the land is then further cleared by burning. Can you think of any reasons why burning is used?

The largest *conucos* always belongs to the headman, and, in this case, occupies about 2 hectares. The others are all about 0·5 hectare. It would have taken about two and a half days to clear the headman's *conucos;* work out how long it would have taken to clear all nine of them.

The vegetation that has not been cleared by the villagers or by the burning is left and the new crops are planted in the debris. This would be useful for two reasons. Can you think what they are?

Polyculture is practised in all the *conucos*, with bananas and manioc the main crops. The Waiku have a technique of arranging the crops so that the taller plants protect smaller ones, also ensuring that there is no earth left bare and unprotected from the wind, rain and sun. If there are large tree stumps or fallen branches, the crops are planted around them. The time and effort involved in moving the obstacles cannot be justified in the context of swidden cultivation, for the few plants that could have been grown in that space can easily be fitted in elsewhere.

Figure 8.25 shows the arrangement of the various crops in the headman's *conucos*. Note the two distinct layers of plants, the taller forming a canopy that protects those below. The rainforest itself is like this, with sometimes up to six or seven layers of growth. In the *conucos*, the tallest plants are the bananas and papayas (commonly called pawpaw in Australia), and occasionally some perennial cotton shrubs. Beneath this discontinuous canopy grow various root crops and vegetables, such as ocumo (similar to the taro of South-east Asia), yam, arrowroot, bitter manioc, bottle gourd, sugar cane, Indian arrowleaf and tobacco. The last two have special significance to the Waiku: the arrowleaf is used for the shafts of their hunting arrows, and the tobacco is chewed and held in the lower lip.

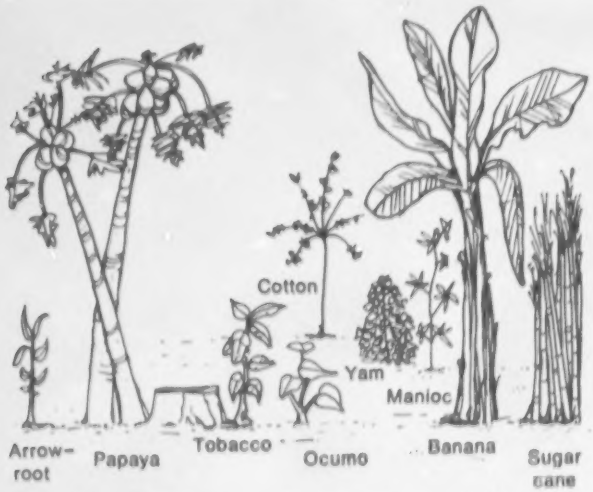


Figure 8.25: Arrangement of crops in a ***conucos***

All these crops would have been planted in February, and the annual weeding of the *conucos* would have taken place in March. So fast is the growth that even in this short time the ground is sufficiently covered with new plants to avoid exposure to the elements.

To the casual observer there seems to be no special pattern in the arrangement of the crops, but because they have different growth rates and root systems this haphazard planting ensures that all available light, warmth, moisture and nutrients are used by the different species. This seems to follow the pattern of natural rainforest growth much more than the ordered one-crop system of more 'developed' farming.

The Waiku cultivate their *conucos* for five or six years. During this time the trees and shrubs that were not killed during the clearing and burning-off start to regenerate. Also, the most aggressive of the forest plants begin to invade the clearing, even while it is still in use. Thus, as the crop yields begin to drop, the forest slowly reclaims its territory.

The yields of different plants decrease at different rates, giving rise to the major differences between the polycultural *conucos* and the monocultural ones. Where there are many crops the *conucos* can be phased out over a period of time, but where there is only the one crop the whole clearing must be abandoned and new ground sought as soon as the yield drops significantly. The variety of plants in the polycultural *conucos* also means that the decline in soil fertility is less rapid than in the monocultural one; with the gradual phasing out of different crops, plant material is returned to the soil, replenishing it to some extent, whereas in monoculture the single crop impoverishes the soil without restoring fertility.

The first plants to decline in yield in the polycultural *conucos* are manioc and ocumo, which show a large fall-off in the second year. Banana trees retain their yield longest, and even after the *conucos* has been 'officially' abandoned the villagers will come back to harvest the fruit. This gathering from previous *conucos* is a very important component of the overall amount that the Waiku produce in order to live. The banana is the only crop that provides a surplus, and this is sent downriver to be sold at Sanariapo and Puerto Ayacucho. Even these unchanged and unaffected Amerindians are not completely subsistence in their mode of life.

Usually, where the *conucos* is monocultural, the area is completely abandoned after two or three years, when the yield falls off appreciably in the case of manioc or maize. Banana *conucos* would maintain their yields for longer periods, but it is seldom that there is not some other crop grown along with the banana. One example of crop rotation has been noted on a monocultural *conucos* —the cultivator intended to follow two years of maize cultivation with two years of manioc.

Among the Waiku, land is held by the whole tribe and no one individual is a landowner, not even the headman. However, the crops grown on the individual's plot belong to him, and thus the headman's larger plot would make him potentially a wealthier man, especially with the selling downstream of surplus bananas. Refer to study 9—is this situation similar to or different from that found in the Abelam tribe of Papua New Guinea?

The Pampas

The Pampas, an arc of grasslands stretching 450 to 650 kilometres inland from the La Plata Estuary, supports three-quarters of Argentina's population, and supplies her chief sources of wealth and most of her exports; 85 per cent of Argentina's cultivated land and 53 per cent of her farms are to be found there. Although less than a quarter of the country's labour force is occupied in farming, the Pampas area supports, directly or indirectly, most of the nine million inhabitants of her gigantic capital, Buenos Aires. Old landowning families form the

upper level of a social hierarchy, living cosmopolitan lives, belonging to exclusive clubs, and wielding considerable political power. The Pampas also provides the raw materials for most of Buenos Aires' large industries—meat freezing and canning, flour milling, tanning and leather works, cotton and woollen textile mills—as well as providing a market for agricultural machinery. The Pampas is therefore the focus of the Argentine economy, and, on a global scale, is a major farming area like the great grasslands of North America, the Soviet Union and, to a lesser extent, Australia.

A flat, stoneless plain, the Pampas was formed when a shallow sea was filled with alluvial deposits and loess (wind-borne particles). The area has porous soils, and most drainage is underground. What effect would this have on the water supply to farms? How could Pampas farmers overcome this difficulty?

Locate Buenos Aires and Bahia Blanca in figure 8.27 (page 72). Study the climatic figures in table 8.4 and try to describe the climate. How does it differ from that of the Amazon Basin? What effect does the proximity to the sea appear to have?

Table 8.4: Climatic statistics for Buenos Aires and Bahia Blanca

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Buenos Aires (25 m)													
Temperature (°C)	23·3	22·8	21·1	16·7	12·8	9·4	10·0	11·1	12·8	15·6	18·9	22·2	—
Rainfall (mm)	78·7	71·1	109·2	88·9	76·2	61·0	55·9	61·0	78·7	86·4	83·8	99·1	950·0
Bahia Blanca (29 m)													
Temperature (°C)	23·9	22·2	20·0	16·1	12·2	8·9	8·9	10·0	12·8	15·6	18·9	22·2	—
Rainfall (mm)	43·2	55·9	63·5	58·4	30·5	22·9	25·4	25·4	40·6	55·9	53·3	48·3	523·3

Figure 8.26: A gaucho of the Pampas **(Secretary of State for Foreign Relations, Brazil)**

On the basis of this information in relation to the topography and climate, try to describe the natural vegetation. Check your hypotheses against figure 8.5 and the natural vegetation map in your atlas.

The early Indians realised the potential of the Pampas for maize growing, and ruled this area from Peru. The Spaniards, crossing the Andes after the Peruvian conquest, introduced horses and livestock to the Pampas, and eventually the *mestizo* (Indian-European) cowboy emerged. In the nineteenth century these *gauchos* roamed the open plains, with cattle providing most of their needs. The *gaucho* became a colourful national figure, in his broad-brimmed black hat, knotted scarf, baggy trousers, silver-decorated belt, and short leather boots; he wore a silver-handled knife at his belt and carried a rawhide whip. Try to identify some of these things in figure 8.26. In what ways would the *gauchos'* costume have suited their hard life riding the Pampas?

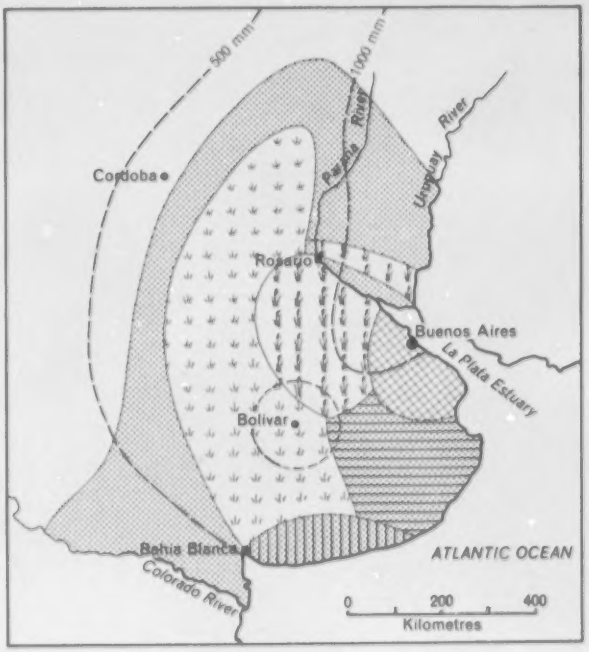
The *gauchos'* independent reign came to an end by the 1880s, when vast changes were sweeping the Pampas. Great estates—*estancias*—had already been established, but these now began to fence their land with cheap, newly-introduced barbed wire, and wind pumps and tanks overcame water-supply difficulties. This allowed the introduction of pedigreed cattle (Shorthorns, Durhams, Herefords and Aberdeen Angus) and the growing of fodder crops like alfalfa, a form of clover. (Which countries, do you think, supplied the barbed wire and the pedigreed cattle?)

At this time, the demand for food and raw materials in industrialised Europe created a great export market for the produce of the Pampas. Railways were built, fanning across the plains, to take farm products to the ports where steamships waited. The greatest boost, however, came from the introduction of refrigerated ships in 1877. Argentine beef could now be frozen and sent to Europe, and meat replaced hides as the major export from cattle. The Pampas was therefore transformed, in the last part of the nineteenth century, into a region of large-scale commercial grazing and agriculture. This link with industrial Europe was obviously a very important influence on the speed at which change was introduced in the Pampas.

This rich new farming area provided an outlet for the increasing population pressure and social and economic discontent in Europe; during the latter half of the nineteenth century over a million Europeans migrated to Argentina, including large numbers of Italian, German and Swiss farmers. The population of Argentina doubled every twenty years, and European influences became strong. Today, for example, whereas only 5 per cent of Argentinians are part-Indian, 40 per cent are of Italian descent. Many immigrants became farm labourers or tenant farmers on the Pampas, but they also provided Argentina with technicians and businessmen.

Today the Pampas farms yield a variety of products, depending largely on location and demand. About 90 per cent of the area is actually farmed, with 50 per cent under pasture and 40 per cent cultivated. On the pasturelands, cattle predominate—Argentina has about 55 million cattle, 10 million of which are slaughtered each year on average. A combination of livestock raising and crop growing is called *mixed farming*. Refer to the information given in figure 8.27, and describe and account for the farming pattern found on the Pampas. Remember to include reference to the climate and topography (already discussed) in your analysis.

The pattern of farming shown in figure 8.27 is very complex. To obtain more detailed information on specific farming activities on the Pampas, we



Pastoral areas: alfalfa used for fodder

Pastoral areas: especially good for cattle breeding (mild climate, tick-free)

Pastoral areas: no alfalfa. Sheep and wheat farming mixed with cattle farming

Intensive dairying and market gardening

Wheat belt: wheat mixed with oats and alfalfa and cattle grazing

Maize (corn) and flax—grown on small farms

Isohyets

Area of study

Figure 8.27: Generalised land use on the Pampas

are going to look at a small farming area at Vallimanca, near Bolivar, about 320 kilometres southwest of Buenos Aires (see figure 8.28). As the area receives an annual rainfall of 760 millimetres and has mild temperatures, farming conditions are good.

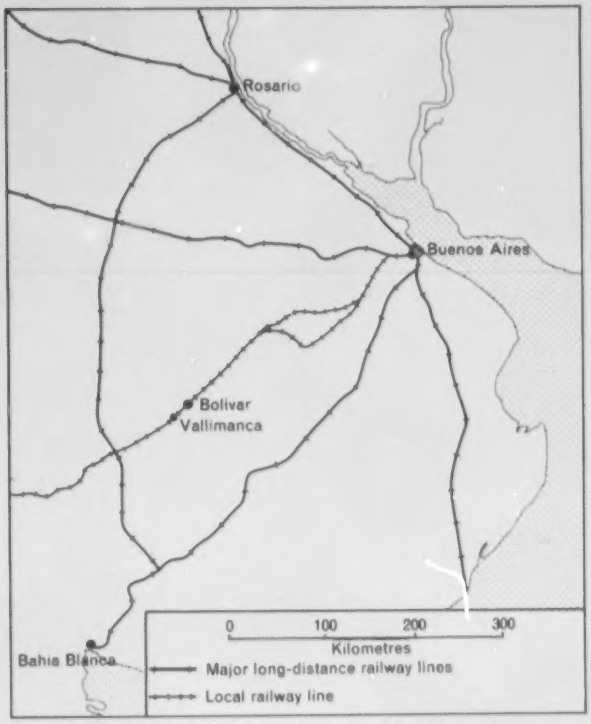


Figure 8.28: Location of Vallimanca

A large *estancia* dominates farming in this area. The original owner, a leading Buenos Aires merchant of Spanish family, was given a grant of 40 000 hectares in the mid-nineteenth century, but this landholding was subsequently divided into three. The present owner of the largest *estancia* lives in Buenos Aires, spending a few weeks each year on his property. There he has a palatial old homestead, the main building surrounded by many outbuildings (stables, garages, tanneries, offices) and recreation facilities (swimming pool, tennis court and polo field). The homestead area is shaded by introduced poplars, eucalypts, conifers, cedars and fruit trees, which stand out on the otherwise treeless plain.

The *estancia*, about 16 000 hectares in area, is divided by wire fences into fields of various sizes (see figure 8.30). The main fields, used for pasture, are each about 400 hectares, and there are smaller fields of wheat, corn and oats. The types of crops grown vary with demand. Wind pumps feed water into troughs for the stock, which vary between 3000 and 5000 head. Numbers fluctuate, for the *estancia* specialises in the fattening of cattle. These are bought at about two years of age and then kept for six to twelve months. Most of the labour is provided by share farmers (*peones*), who are given a small adobe house, a garden plot and a meat ration. These cattle hands and farm labourers live in a central group near the *estancia* homestead.

About 5250 hectares of the *estancia* has been divided into 28 farms of varying sizes, leased to tenants, mainly Italian and other European settlers (see figure 8.29). Some farms, the *chacres*, are quite large, and are subdivided like the *estancia*. Most, however, are small one-family farms ranging from 8 to 280 hectares. The tenant rents the land from the *estancia*, and pays for his own seed, stock and equipment. More independent than the share farmer, he works to get as much return as he can from the land. Wheat is the main crop on most small farms, but the area under cultivation fluctuates according to demand. Tenants also grow oats and corn and may keep some hogs (see figure 8.30). When he eventually moves on to another farm, the tenant leaves the land under alfalfa for the *estancia* owner. The tenant's house is usually in the centre of the farm, surrounded by corrals, and he and his family live a little more comfortably than the share farmer. Land is leased, however, under a short contract, and the tenant has almost no chance of buying his own land. What are the advantages and disadvantages of such a system?

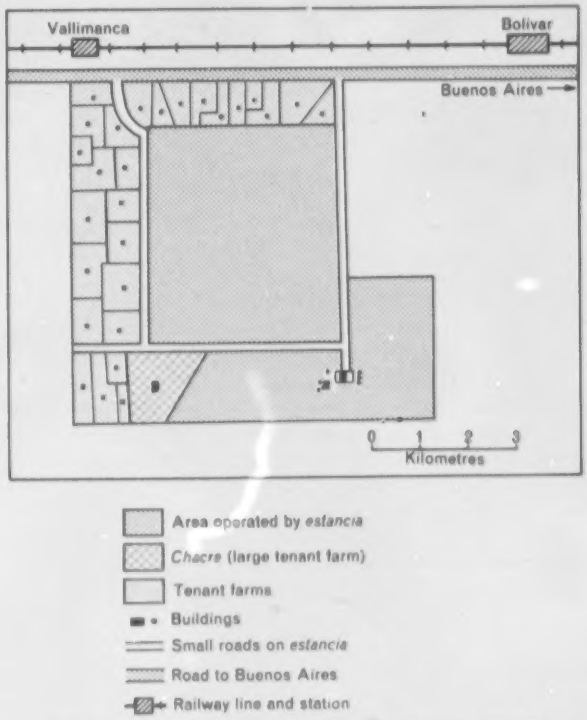


*Figure 8.29: Subdivision of the **estancia** into separate farms*

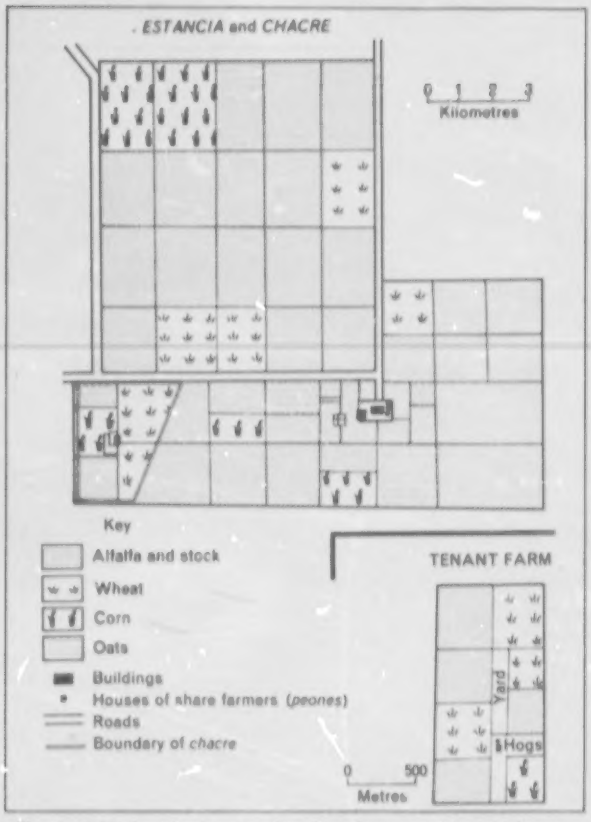


Figure 8.3C: Land use on ***estancia, chacre*** *and tenant farms*

The produce from the different farms goes by dirt roads to the railway station at Vallimanca. Railway lines radiate out from Buenos Aires like a fan, with stations every twelve to twenty kilometres. Supplies and services come from Bolivar, the centre of collection and distribution for the area. There are many such towns on the Pampas, with populations ranging from 10 000 to 40 000. There are, however, no large inland cities, for, unlike other large grasslands, the Pampas extends to the coast and the great ports. At centres such as Buenos Aires and Bahia Blanca, goods are processed and exported, or sold locally on the large home market.

Change continues on the Pampas, though improvements are often slow. Many tractors are used, and machines have replaced much seasonal labour, forcing rural workers to seek employment in urban industries. The government provides silos and terminal facilities, and maintains standards, as the goods of the area are vital to the country's economy. However, overseas demand has dropped, largely because other countries are protecting their own farmers. The United States has now replaced Europe as the major market for Argentine goods.

Farming on the Pampas, advanced as it may appear in comparison with the other South American areas we have examined, could be more efficient and productive. Productivity is hampered by traditional farming methods and land ownership. Land is often held for status rather than for high yield (and even today, 6 per cent of the total number of farmers own 75 per cent of the land), modern techniques have not been fully utilised, and output has remained stagnant. Physically, the Pampas is similar to some areas of Australia, and the same farming products are important to each country (see table 8.5, comparing farm industries in Argentina and Australia). But when we come to land control and ownership, a different picture emerges, for Argentina suffers from the vast inequalities so noticeable throughout other countries of South America.

Table 8.5: Comparison of some farm industries in Argentina and Australia, 1968

	Argentina	Australia
1. *Wheat*		
Area (hectares)	5 860 000	9 082 000
Production (tonnes)	5 740 000	14 687 000
% of world production	2%	4%
% of local production exported	36%	56%
2. *Cattle*		
Number	51 465 000	19 182 000
% of world total	5%	2%
Beef and veal (tonnes)	2 546 000	965 000
% of world production	7%	3%
% of local beef and veal exported	15%	16%
3. *Sheep*		
Number	47 800 000	166 912 000
% of world total	5%	16%
Wool production (tonnes)	180 000	880 000
% of world production	7%	32%
% of local wool production exported	59%	78%
Mutton and lamb (tonnes)	212 000	625 000
% of world production	3%	10%

Sources: United Nations Statistical Year Book, 1969; United Nations Year Book of International Trade Statistics, 1967; Commonwealth Year Book, 1969

The farmers of the Pampas are, however, relatively prosperous in comparison with those in many other parts of the continent. Their contact with the outside world has forced them to change. Great and small, they play a major role in the economy of Argentina, and in the picture of that elusive person, the 'South American'.

We have seen marked contrasts in these studies of food production in different parts of South America. On the basis of the knowledge you have gained, try to draw diagrams representing the farming systems in the Peruvian Andes, in the

Upper Orinoco rainforest, and on the Pampas of Argentina. Remember to note links with overseas countries, and give some indication of the comparative rates of change in the three systems.

In urbanised societies many people live in cities and don't produce food for themselves; would each of these systems of production be able to satisfy the needs of such societies? What are the differences in the three farming systems whereby one method produces a lot of food in relation to the number of people involved, and the others, in comparison, produce much less?

9

Food production in Papua New Guinea

In Papua New Guinea, crops are the main source of food. Figure 9.3 shows the distribution of the different types of food crops. In Level One, *Man and Space*, you studied the Kerema Bay district, an area in Papua New Guinea where the people's staple food was sago. Compare its location with the distribution of food crops as shown in figure 9.3.

In this study we are going to examine another area in Papua New Guinea quite distant from Kerema Bay.

THE ABELAM

The Abelam are a tribe of shifting cultivators who live about 65 kilometres west-south-west of Wewak in the Sepik district (see figure 9.1). The tribe numbers about 30 000, the majority of whom live in a 750 square kilometre foothill area of the Alexander Mountains at an elevation of between 120 and 300 metres above sea level. The average population density is approximately 40 people per square kilometre, but in parts the density rises to over 150 people per square kilometre, which is high for shifting cultivators. Population density is one of the critical factors among shifting cultivators; can you think why?

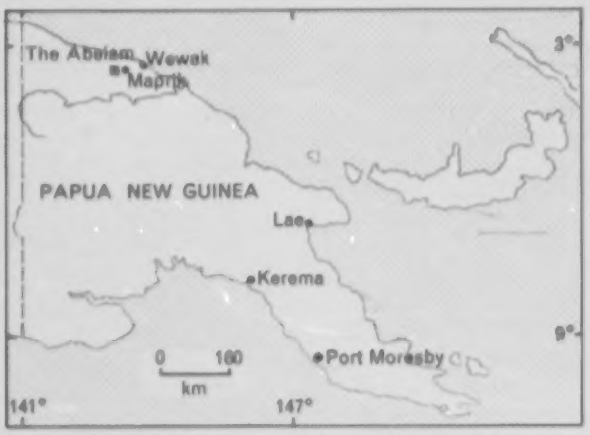


Figure 9.1: Location of the Abelam people

The tribe is subdivided into villages numbering from 300 to 800 people, who live in well-defined areas with boundaries that were carefully guarded and often fought over before tribal fighting was suppressed in the 1930s by the Australian administration. Rights to use village gardening land are held by clans or sub-clans, which are thought to be related through a common male ancestor. Gardens are scattered throughout the village lands, which may extend for about 800–1600 hectares (figure 9.2). The economy of the Abelam—indeed their whole way of life—is based on the cultivation of yams in 'gardens' (the name given to their farm plots). Many other crops are interplanted; the most important is taro, while all gardens would include bananas, beans (many different types), leafy vegetables and maize. Among the other crops that are often planted are cucumbers, pumpkins, tobacco, pawpaw, peanuts, sweet potatoes, manioc and sugar cane.

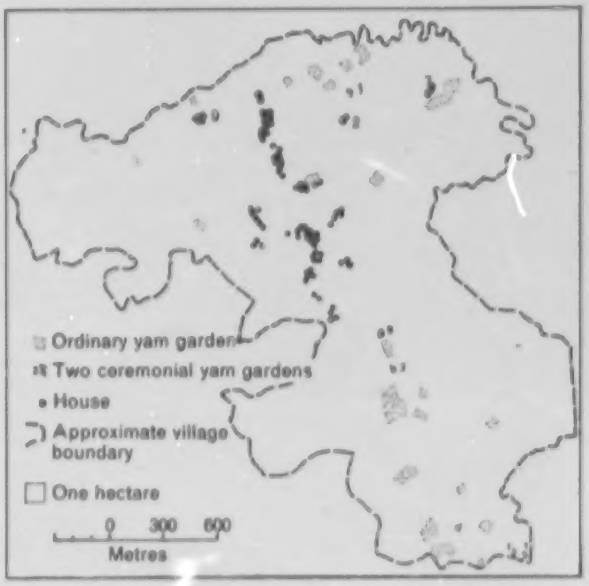
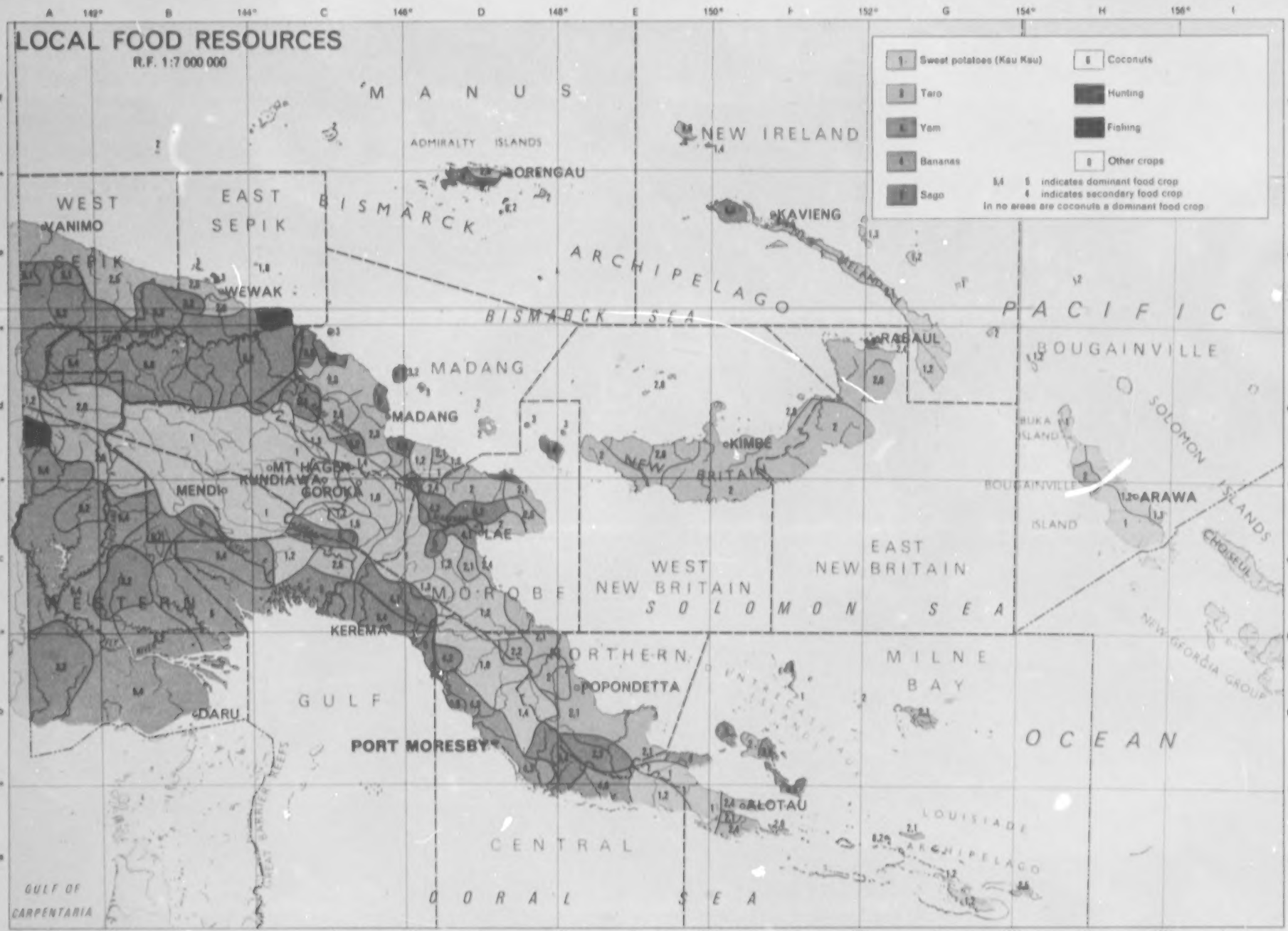


Figure 9.2: Distribution of gardens throughout the lands of Yenigo village

Figure 9.3: Local food resources, Papua New Guinea ▸


LOCAL FOOD RESOURCES
R.F. 1:7 000 000
1 Sweet potatoes (Kau Kau)
2 Taro
3 Yam
4 Bananas
7 Sago
6 Coconuts
Hunting
Fishing
8 Other crops
5,4 5 indicates dominant food crop
4 indicates secondary food crop
In no areas are coconuts a dominant food crop
MANUS
ADMIRALTY ISLANDS
NEW IRELAND
KAVIENG
KOREGAU
WEST SEPIK
EAST SEPIK
VANIMO
WEWAK
BISMARCK ARCHIPELAGO
BISMARCK SEA
PACIFIC
RABAUL
BOUGAINVILLE
SOLOMON ISLANDS
MADANG
MADANG
KIMBE
NEW BRITAIN
BUKA ISLAND
BOUGAINVILLE ISLAND
ARAWA
CHOISEUL
MENDI
MT HAGEN
KUNDIAWA
GOROKA
LAE
WEST NEW BRITAIN
EAST NEW BRITAIN
SOLOMON SEA
WESTERN
MOROBE
KEREMA
NORTHERN
POPONDETTA
MILNE BAY
GULF
DARU
PORT MORESBY
OCEAN
ALOTAU
LOUISIADE ARCHIPELAGO
CENTRAL
CORAL SEA
GULF OF CARPENTARIA
NEW GEORGIA GROUP

A typical Abelam garden would be around 0·2 hectare in area, containing about forty different crops. Its life span would be about two years, but it would be cultivated intensively for only nine or ten months. The garden would then be left fallow for at least eight years, and often much longer. However, the average length of the fallow period is restricted by population pressures to a maximum of fifteen years, so that tropical rainforest, with its complex system of different plant forms, rarely has a chance to re-establish fully.

The agricultural cycle follows the seasonal rainfall distribution (see figure 9.4). The heaviest rainfall is received from January to April, brought by the north-west monsoon. From May to October there is a drier period, but at no time during the year is there an actual dry season. (Why not?) At the end of the drier season the agricultural cycle begins with the clearing of the forest. As the rains begin to come again the yams are planted, from October through to January. They take about seven months to mature and are therefore harvested during the comparatively dry season from May to September. Other crops are planted as seed material becomes available, and are harvested and eaten when mature.

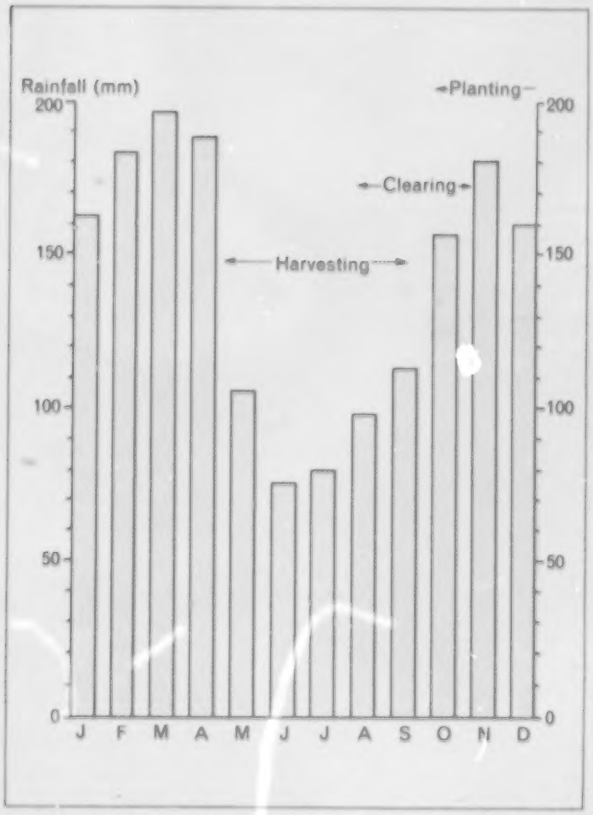


Figure 9.4: Average annual rainfall at Bainyik, 5 kilometres south of Maprik

The life cycle of a garden

Garden sites are selected at least a year before they are used. The rights to land and the way that land is distributed in the Abelam community are very complex subjects, and so, leaving aside the question of legality (in the Abelam cultural context), the land is selected mainly on the basis of its previous performance and nature's own indicators of suitability. The Abelam believe that if the trees are light green in colour, or if a certain fern is growing, then the ground has not been rested long enough; the presence of white ants indicates that the soil will not hold water, for they believe that ants only like dry places and never frequent wet ones. A practical understanding of soils has been learned by many generations of Abelam, and they know the type of ground that will best suit their agricultural activities.

A family has one main garden, divided into a number of garden blocks (see figure 9.5). The head of the family keeps about half of the blocks for his own use and then distributes the rest among his kinsmen or close friends. One family will therefore be concentrated in a single area, so that labour can be pooled and tasks shared to a small degree. In addition, they will have scattered plots in other parts of the village, to which they have been given rights.

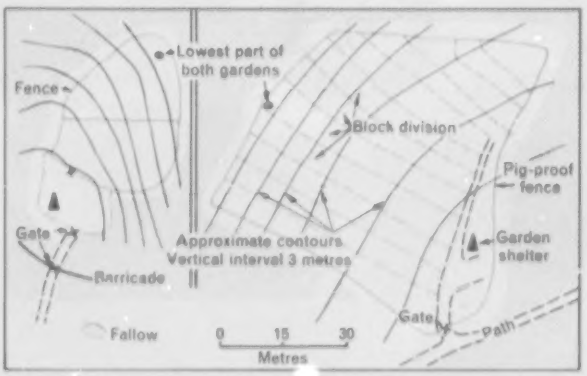


Figure 9.5: Examples of typical Abelam gardens. On the left are two ceremonial yam gardens, both 400 square metres in area and each containing 26 large yams. At right, an ordinary yam garden 0.3 hectares in area and containing 696 small yams, 1979 taro plants and many other plants

It takes from two to three months to cut down the forest and prepare the site for planting. The undergrowth has to be slashed, and the small trees, creepers and vines cut out. Larger trees are then notched about two-thirds of the way up the trunk by the men, and the largest tree at the top of the garden is felled in such a way that the upper sections of all the notched trees are brought down. The trunks and some of the smaller trees are left to form a basis for the trellises over which the yams

will grow. Some material is saved for the fence that has to be erected to keep out both wild and domestic pigs, and all the rest is burned after a drying period of three to four weeks. As the first burning is never sufficient, the charred rubbish is heaped around the remaining stumps and burned again. The men do the heavy work, while the women do the final clearing and tidying of the garden. At this stage the ground is left bare over much of the garden area, and soil erosion is a possibility, but the Abelam put their unburnt logs at intervals along the contours and heap up all the unburnable rubbish and ashes against them, thus controlling run-off. In any case, the seeds are now planted and the crops in this tropical environment very quickly cover the soil. The women prepare the ground for the sowing of the crops, while the men erect the protective fence and a small shelter that will shield the cultivators from sun and rain when they are not actually working in the garden blocks.

The yams are planted first, using seed yams that have been stored for this purpose. Yams store very well, even in this tropical, humid climate—they are the only vegetable crop that does not have to be eaten as soon as it is harvested. Seed yams that have been stored for around six months will have a shoot about 60 centimetres long. The yam is put into a hole 45 centimetres deep that has been made using a primitive digging stick and the hand. It is planted in such a way that it sticks up above the ground, and then soil is heaped over it to form a mound about 40 centimetres high. The men do all the planting of yams in both the ordinary and the special ceremonial gardens, the women being forbidden to touch them. The women do the rest of the work in the ordinary gardens. They plant all the other crops, weed the gardens and harvest these crops as they ripen.

The ceremonial gardens are smaller than the ordinary gardens, with an area of about 0·04 hectare (figure 9.5). Only thirty yams can be grown in this space, but the Abelam are so skilful that they produce yams up to 4 metres in length. (A normal yam would be the size of a large potato, about 25 to 30 centimetres.) The yam is a status symbol to the Abelam; the growers of the largest yams acquire a great deal of prestige and are the leaders of the village. Women are rigidly excluded from these special gardens, for the men practise much magic and observe strict taboos in growing the ceremonial yams.

When harvest time comes the men again do all the work concerning both the ceremonial and the food yams. The tools used are simple sticks and the hands. Most gardens in other areas of New Guinea yield 2–4 kilograms of yam per hole, but the Abelam are so successful in their methods that they can harvest an average of 9 kilograms per hole. After the yams have been dug from the ground they are carefully cleaned and deposited in special storehouses, either in readiness for eating or to be preserved as the seeds for next year's crop.

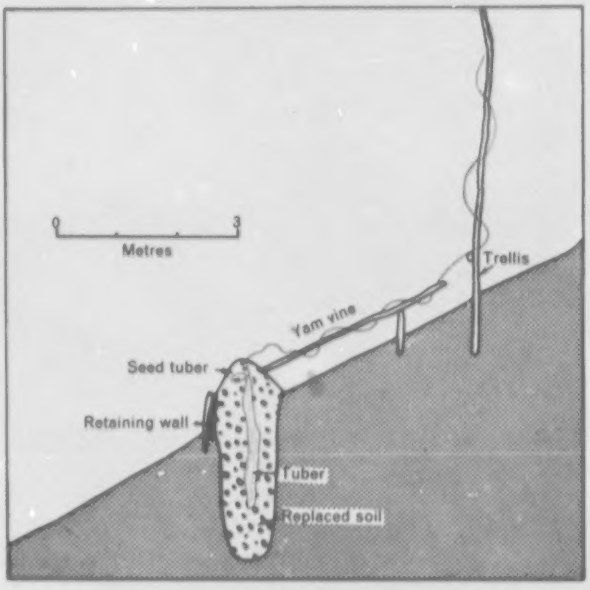


Figure 9.6: Cross-section of a ceremonial yam hole. The trellis is often 8–10 metres high

The main work of the garden is now finished, and for the remaining twelve to eighteen months it will yield only bananas and minor crops. The women no longer weed it and slowly it passes into disuse, although seeds will be collected in its dying stages for planting in the new gardens now being prepared. If the fence is not maintained, the pigs will eventually break into the garden and eat the remaining vegetables.

The forest now begins to take over again. Weeds are the first invaders, then bushes and finally the trees. As the trees become more dominant they shade out the weeds below, and the forest is re-established.

Carefully examine the colour illustrations on pages 80–81, answering the questions posed in the captions.

- Figures 9.7–9.9 illustrate village layout and the nature of individual constructions (note the yam storehouse in figure 9.9).
- Figures 9.10–9.13 illustrate preparation and planting of the gardens (identify the seed yam and shoot in figure 9.12).
- Figures 9.14–9.17 illustrate garden crops and layout.

There are a number of similarities between the food production methods of the Abelam of Papua New Guinea and the Amerindians of the Orinoco rainforest. In what ways are the systems similar and in what ways are they different?

Figure 9.7: An aerial view of a typical small village. The houses are arranged around the ***amei*** *(ceremonial dancing ground) in front of the* ***haus tambaran*** *(the men's meeting house and spiritual centre of the village)*

Figure 9.8: A closer view of the village with the ***haus tambaran*** *in the background*

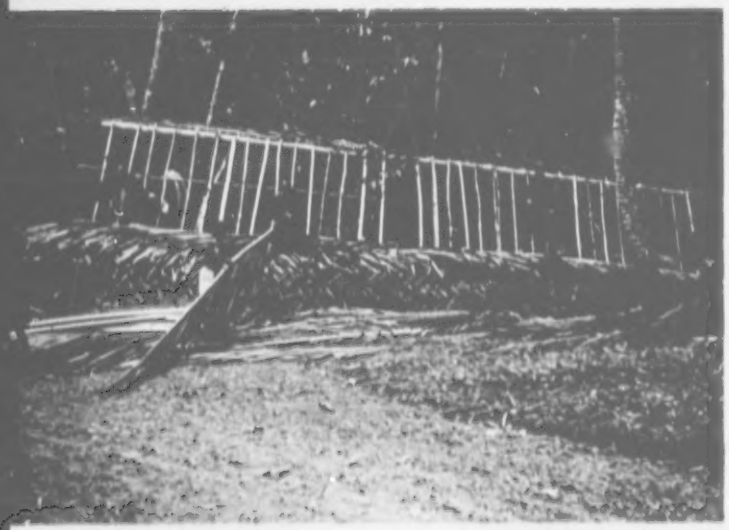


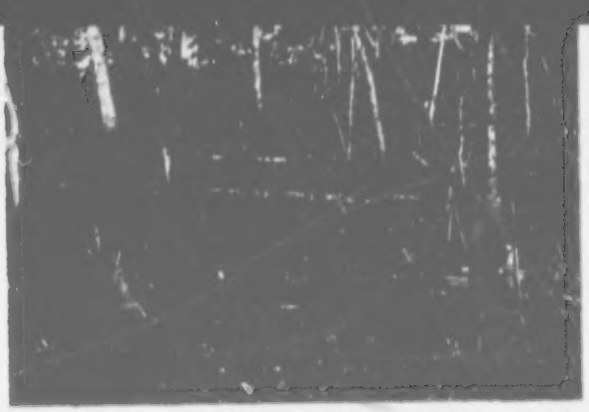
Figure 9.9: Building a new yam storage house. Describe the methods and materials used, and their advantages and disadvantages

Figure 9.10: Preparing new gardens. The forest growth has been cut down and is ready for the first burning

Figure 9.11: After burning, the ground is prepared for planting. Describe the activities and features

Figures 9.12 and 9.13: Yam planting in progress. The potential for erosion is obvious—what features might counteract this problem?

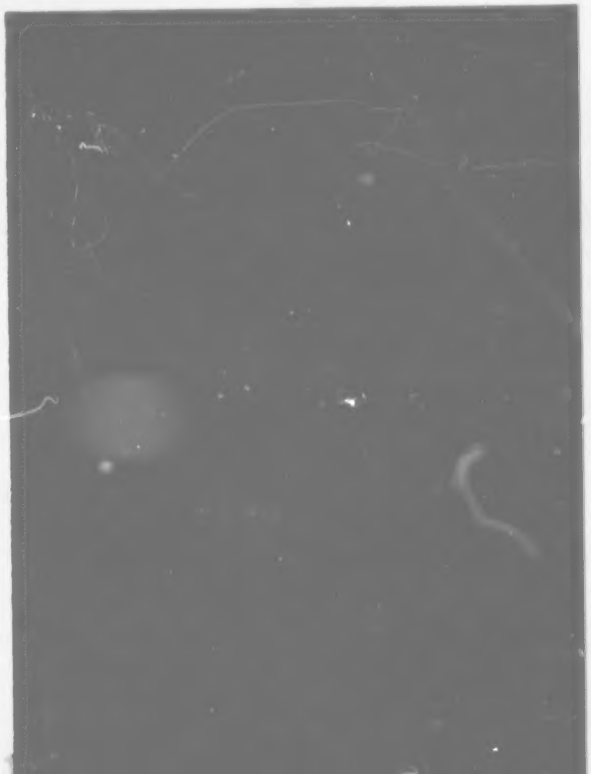
Figure 9.13



Figures 9.14 and 9.15 (below): Note the variety of crops in these gardens. How many can you identify? What erosion control measures are being used?

Figure 9.16: Yam plants with interplanted taro and bananas. What other features can you see? Using this photograph and others of the accompanying illustrations, describe the methods used in cultivating yams. Comment on the implements employed and the appearance of the garden when the task is finished

Figure 9.17: An aerial view of garden land. Coffee gardens have a fairly even canopy of light green, and sago palms are grown in swamps or creekbeds. Draw a field sketch from this photograph and label newly-cleared or burnt-off gardens, newly-planted gardens, coffee and sago gardens, a small hamlet and a garden shelter



10

Sugar production in Fiji

Examine table 10.1. This shows the area planted to major crops in Fiji and the importance of two of the crops.

Make a tracing of the two large islands, Viti Levu and Vanua Levu, from figure 10.1; include the provinces. Refer to table 10.2, determine the major crop (by area) for each province, decide on a key and shade the map to show the distribution of these crops. Describe the general pattern of distribution of the different crops and of sugar in particular.

The sugar cane plant is a grass (genus *Saccharum*) that grows throughout Fiji and other Pacific islands; however, it was not grown in Fiji as a commercial crop until about 1870. The industry was set firmly on its feet when an Australian company, the Colonial Sugar Refining Company, became interested in Fiji and built the first sugar mill at Nausori in 1882. Originally the cane was grown on large estates, mostly with indentured Indian labour, but after the system of indenturing was abandoned in 1916 the large plantations were gradually broken up. (See study 21 for more detail on the history of Fiji's sugar industry.)

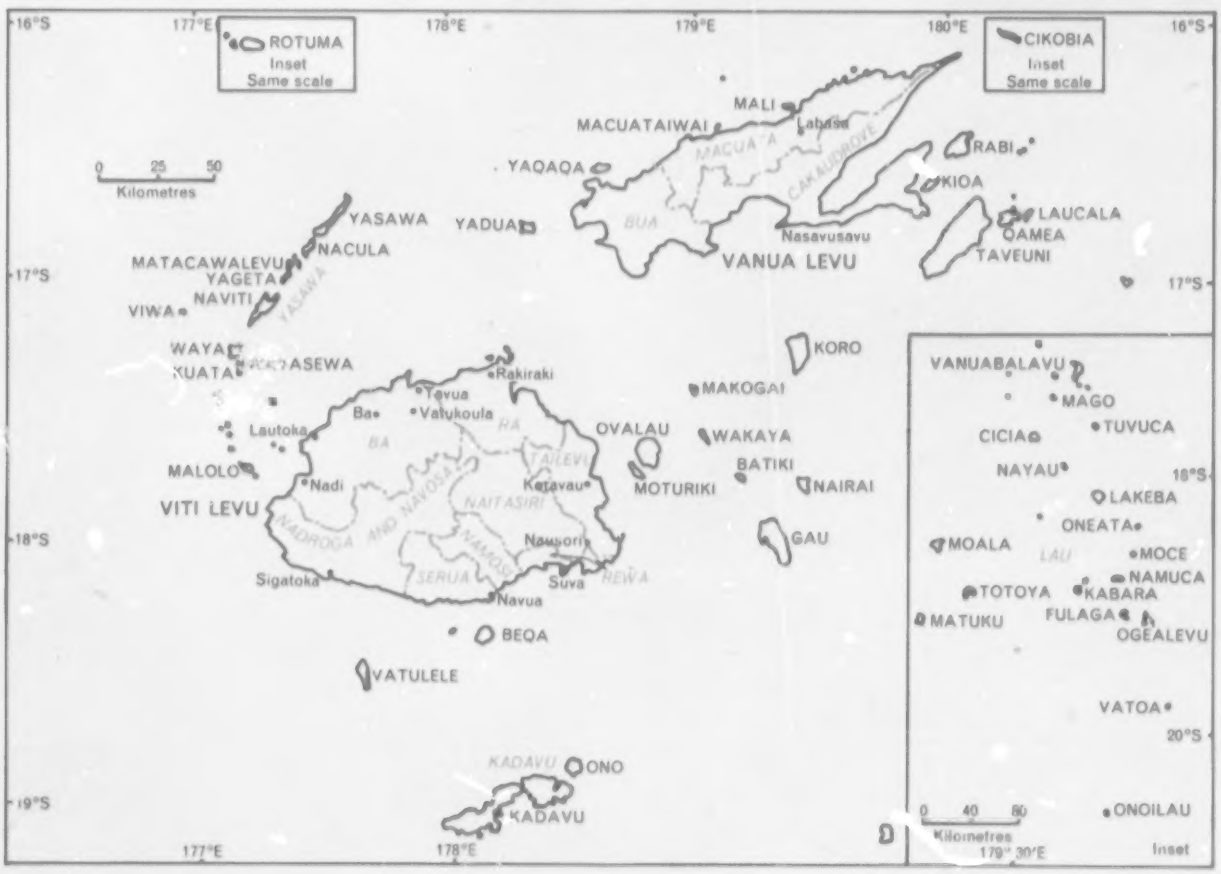


Figure 10.1: The Fiji Islands

Table 10.1: Fiji—areas of major crops

Crop	Area (hectares)	Crop	Area (hectares)
sugar cane	* 53 193	sorghum	418
coconuts	72 320	yams	1 468
bananas	4 097	yaqona*	3 085
dalo*	4 682	cocoa	2 190
cassava*	6 902	tobacco	418
rice	9 855	beans	654
groundnuts	789	pigeon peas	696
maize	1 519	melon	320

*Dalo and cassava (manioc or tapioca) are plant roots that are edible when cooked; yaqona (pronounced *yanggona*) is the root of a plant that is powdered and dissolved in water to make a drink sometimes called *kava*.
Source: *Report on Census of Agriculture*, 1968

What are the cane farms like today? Figure 10.13 (taken in June) and figures 10.2–10.5 (taken in August) show features of the present-day cane farm layout. Make a tracing from the vertical aerial photograph to illustrate the shape and pattern of the plots. The various shadings suggest stages of crop growth, and more detail can be seen in the colour photographs. Account for the variation in shading (further information will be available as you read on).

Seed cane is planted from February to May so that growth will be established before the dry season. Harvesting takes place fourteen to eighteen months later for the *plant crop* (the first crop of cane harvested after planting); *ratoon crops* (generally two or three) are also harvested subsequently, the first usually twelve months after the plant crop—the ratoon cane grows from the original stools or stubble left in the soil when the stalks are cut at ground level during harvesting. Crops are usually harvested between June or July and December, when the cane is well grown and the sugar content is high. The average yield for Fiji is approximately 1 tonne of raw sugar to 7 tonnes of cane.

Figures 10.6–10.12 show various agricultural tasks being performed. Describe these activities. All of the photographs were taken during August and provide further information in explaining the landscape pattern referred to previously.

Throughout the year the work is done by the farmer and his family, but both Indian and Fijian canecutters are employed during the harvest. Oxen or working bullocks are used for pulling ploughs and carts, but the number of tractors in use (often communally owned) is growing.

Table 10.2: Fiji—areas of major crops by province

Province	Crop	Area (hectares)	Province	Crop	Area (hectares)
Ba	sugar cane	29 483	Cakaudrove	sugar cane	507
	coconuts	330		coconuts	29 777
	bananas	156		bananas	2 557
	dalo	131		dalo	1 692
	cassava	803		cassava	1 363
	rice	2 152		yaqona	1 275
	maize	427		cocoa	1 751
	pigeon peas	546		rice	248
Nadroga and Navosa	sugar cane	7 825	Macuata	sugar cane	11 321
	coconuts	936		coconuts	6 498
	cassava	709		bananas	165
	rice	1 185		cassava	870
	maize	586		rice	2 643
	tobacco	313		beans	291
Serua	coconuts	282	Rewa	coconuts	212
	cassava	73		cassav	166
	rice	199		rice	159
Bua	coconuts	7 369	Nailaslli	coconuts	264
	bananas	210		bananas	426
	dalo	170		dalo	689
	cassava	602		cassava	372
	rice	1 123		rice	1 045
Tailevu	coconuts	1 366	Namosi	dalo	94
	dalo	161		cassava	44
	cassava	546		yaqona	92
	rice	842	Ra	sugar cane	4 002
	bananas	161		coconuts	498
	maize	159		cassava	248
	cocoa	192		rice	248

Source: *Report on Census of Agriculture*, 1968

Figure 10.2: Cane fields near Nadi

Figure 10.3: Cane fields near Nadi

Figure 10.4: Cane fields near Nadi

Figure 10.5: Cane fields near Nadi

Figure 10.6: A Fijian ploughir_ cane field

Figure 10.7: An Indian farmer preparing the ground

Figure 10.8: Indian women cultivating cane

Figure 10.9: Fijian labourers cutting cane

Figure 10.10: Fijians loading cut cane

Figure 10.11: Working bullocks at rest

Figure 10.12: Mechanisation in the cane fields

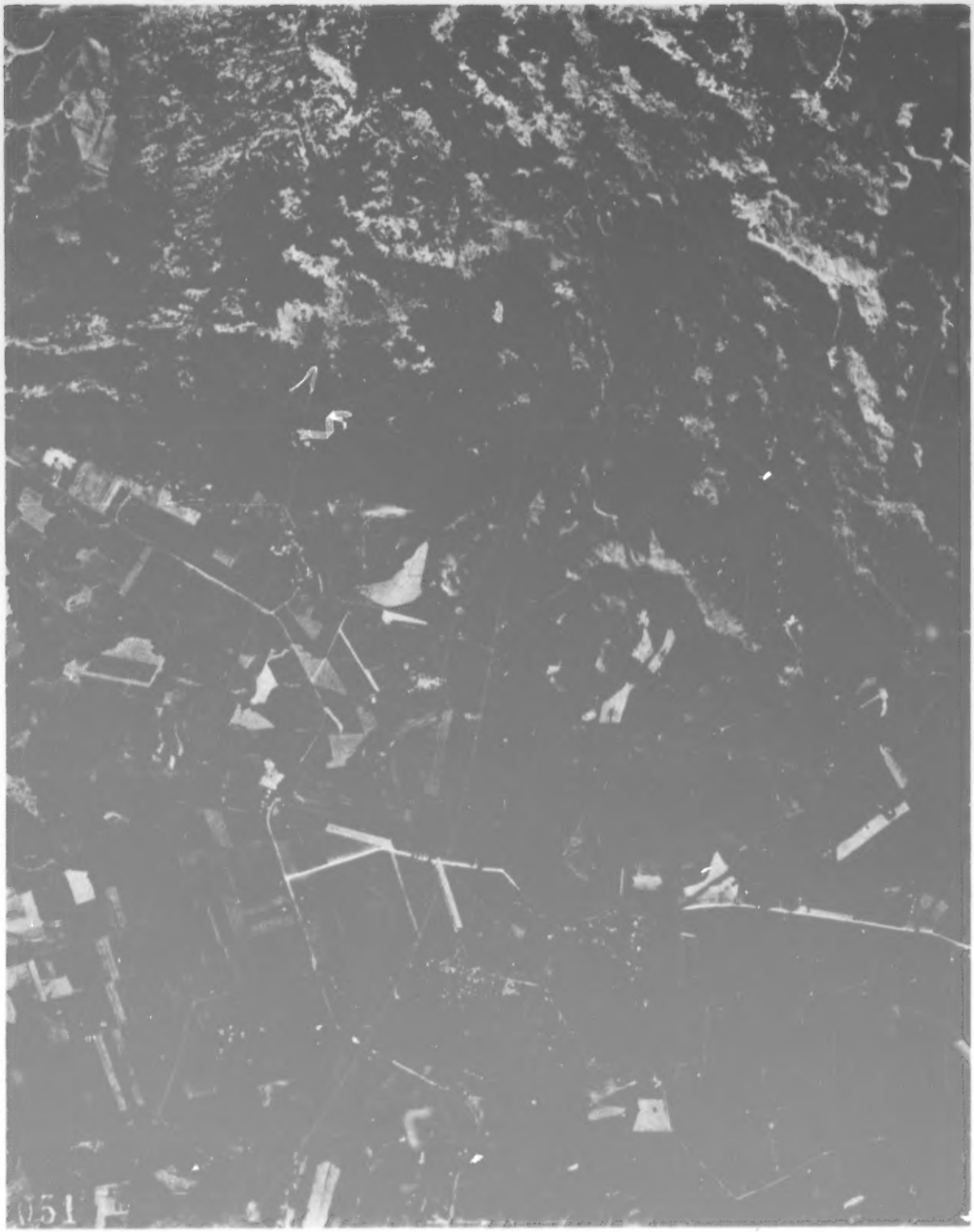


Figure 10.13: Vertical aerial photograph of a cane growing area of Viti Levu ***(Reproduced with permission from the Ministry of Lands and Mineral Resources, Fiji)***

Which of the photographs suggest traditional methods of cultivation? Figure 10.12 shows a more recent trend—the use of mechanical energy. Suggest some reasons for the change. What other changes in traditional methods could follow? However, the use of muscle power is still widespread. Figure 10.14 shows the distribution of working bulls and horses by provinces; try to relate this to the area under sugar cane in each province (table 10.2).

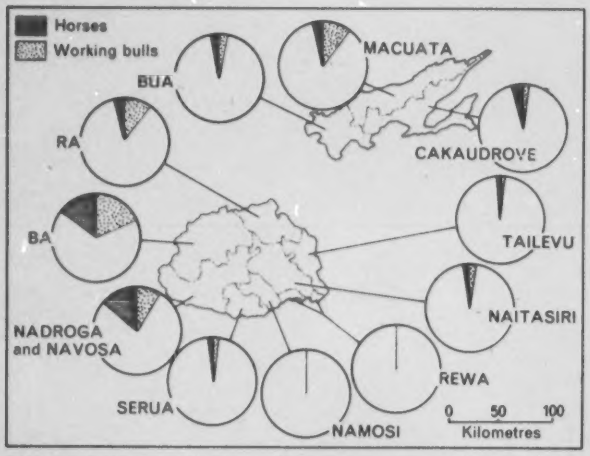


*Figure 10.14: Distribution of horses and working bulls by province (Source: **Report on Census of Agriculture, 1968**)*

The cropping cycle on land for cane is usually one-third plant cane, one-third ratoon and one-third legume or green manure crop, generally Mauritius bean or cow pea. The green manure crop is ploughed back to replace nitrogen and help restore soil fertility. Rice is grown as a food supply, but the mills limit the area to 0·4 to 0·8 hectares per farmer, because the growing of rice tends to leave less area available for green manure crops and can also delay the planting of cane on that ground. Rice takes about five months to grow and is harvested in April or May.

Indian farmers originally obtained land under a Colonial Sugar Refining Company (C.S.R.) lease, but various types of land tenure exist today. Figure 10.15 shows land tenure and sizes of holdings for both Indian and Fijian farmers (all farmland, not just cane farms). *Mataqali* is Fijian communally owned land, and N.L.T.B. land is Fijian-owned land leased through the Native Land Trust Board. Compare the sizes of holdings and the tenure of Fijian and Indian farmers.

Settlement patterns and housing types reflect a blending of cultures: Fijian, Indian and European. Figures 10.16 and 10.17 show two Indian farmhouses. Refer to study 21 on the social background of Fiji—what features of the society are reflected in these photographs?

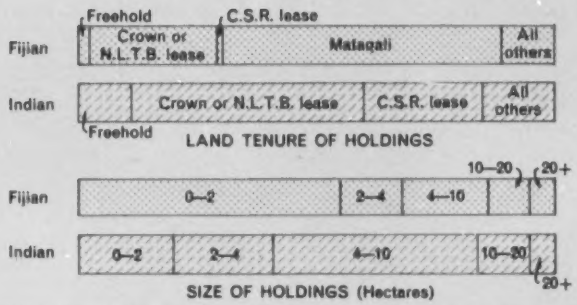


*Figure 10.15: Land tenure of holdings and sizes of holdings, Fijian and Indian farmers (Source: **Report on Census of Agriculture, 1968**)*

Figure 10.16: An Indian farmhouse near Nadi

Figure 10.17: An Indian farmhouse on the north coast of Viti Levu

Make a tracing from figure 10.13, marking the location of each building with a dot and drawing in the roads. Locate the area covered by the vertical aerial photograph in the map extract, figure 10.18. Describe the settlement pattern. Cane farms are reasonably close to large service centres such as Nadi (figures 10.19 and 10.20).

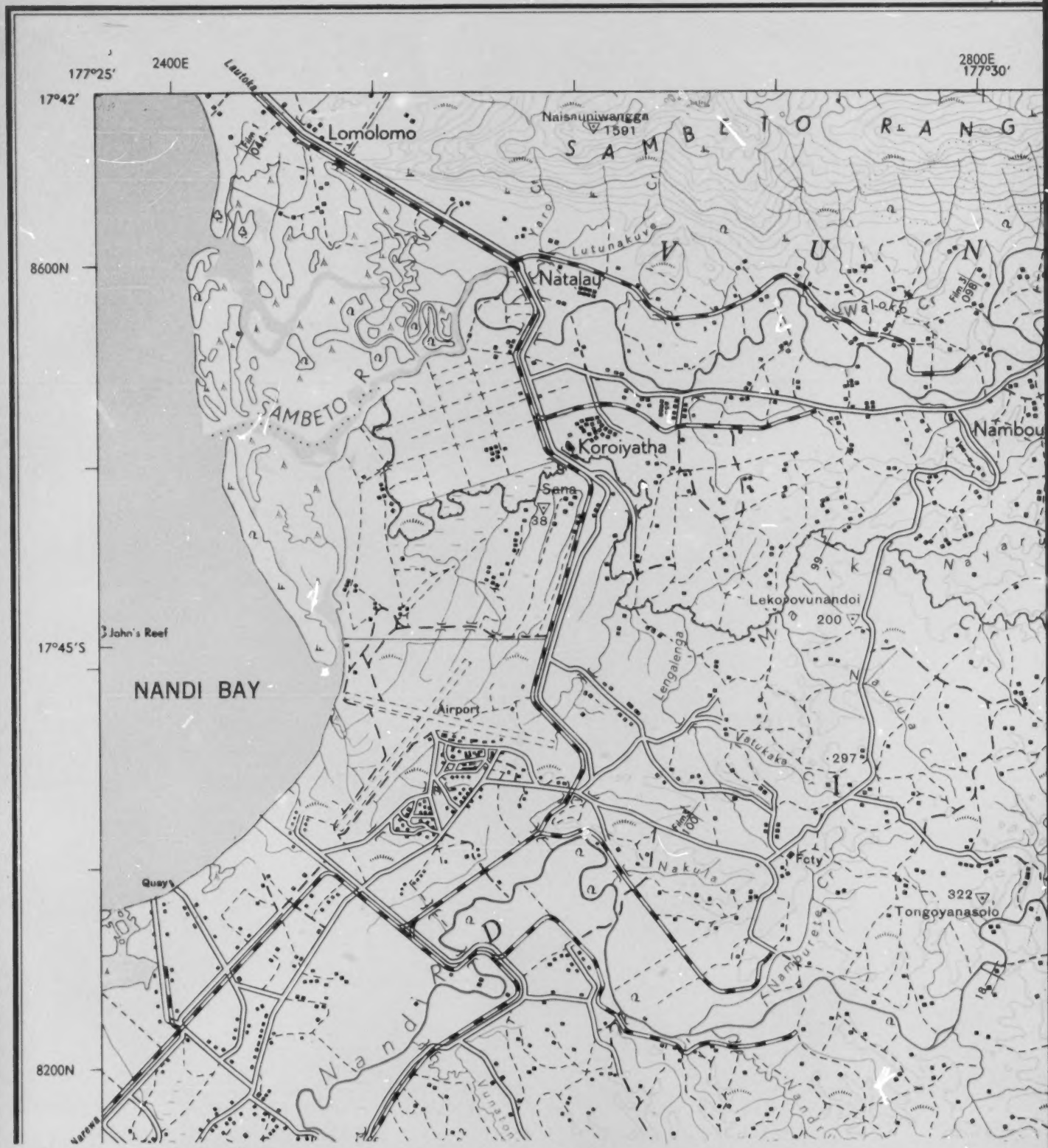


Figure 10.18: Map extract—Viti Levu, sheet 10, 1 : 50 000 ***(Reproduced with permission from the Ministry of Lands and Mineral Resources, Fiji)***

Figure 10.19: Oblique aerial view of Nadi township

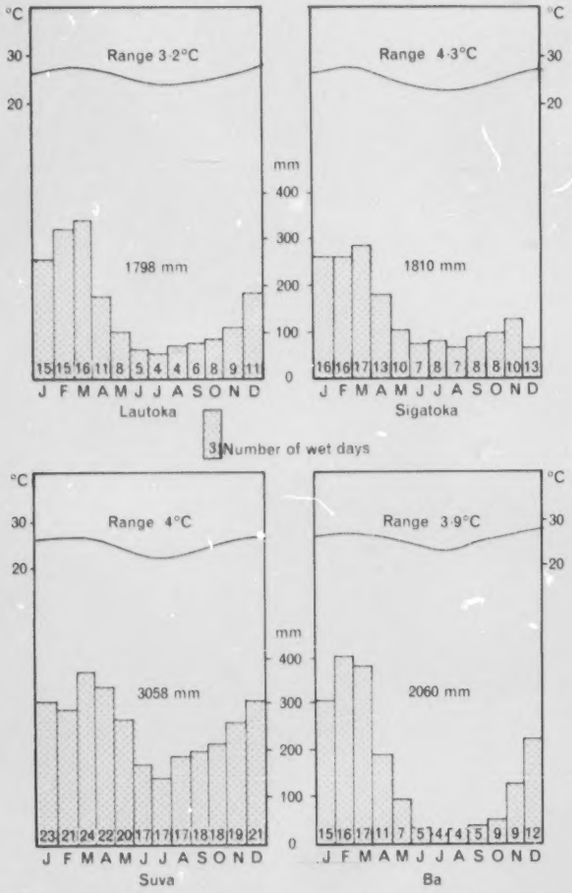


Figure 10.21: Climatic graphs ***(Fiji Meteorological Office)***

Figure 10.23: Native grasses

Figure 10.20: Shops in Nadi

Figure 10.22: Tropical rainforest

Figure 10.24: Mangroves

BEBE BELTS ISLANDS AT 140mph

By ALAN DEARN, who phoned Fiji today

About 200 Australian tourists today sheltered in thatched huts and hotel basements in Fiji resorts as Hurricane Bebe swept down with 140 mph winds.

This afternoon Nadi was out of communication with the rest of the world after emergency radio bulletins warned that the hurricane was due to hit.

The hurricane left a swathe of destruction as it tore into north-west Fiji today.

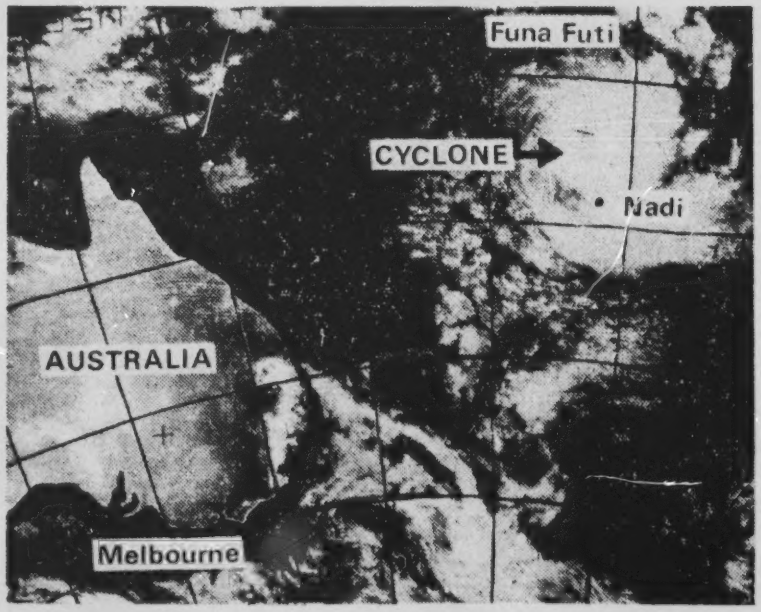
AAP reported that a Royal New Zealand Air Force pilot who had flown over hurricane-battered islands north of Fiji said today: "It is one of the worst disasters in the South Pacific this century."

BELOW: This is Hurricane Bebe, photographed by weather satellite 800 miles above the earth.

A series of pictures were radioed from the satellite to Melbourne, and made up into a mosaic by the Weather Bureau.

An artist has outlined Australia and drawn in the latitude and longitude.

The satellite automatically radios its pictures of the earth's weather to Melbourne as it passes over Australia each day.



A Qantas jet pilot, Capt. G. Bailey, said in Sydney today: "It was a race between us and the storm to see who would make Fiji first. The hurricane won.

"Conditions did not permit us to land, but even if we could have made it down, we would not have got out again."

Rivers are rising and a flood warning has been issued for southern Viti Levu, Fiji's main island.

Roads are cut in many parts of the island.

All roads on the third island of Taveuni are cut, and on Viti Levu the main coastal road between Lautoka and Suva is cut by falling trees and floods.

Fiji's population is 500,000.

"Viti Levu has battened down for the worst hurricane in 20 years," Mr J. E. "Bill" Allen, 52, the Qantas manager at Nadi said today.

Mr Allen said by radio telephone from Nadi that driving winds of 50 mph were being recorded on the runway.

He said: "The airport is evacuated, and the shops are closed. It is a tense atmosphere.

"Weather reports say the hurricane swept over the Yasawa Islands early today where there are many tourists including some Australians.

Figure 10.25: Melbourne ***Herald****, 24 October 1972*

Thousands left homeless

Hurricane Bebe, which tore through Fiji on Monday and Tuesday, killed at least 13 people and left thousands homeless.

The death tally mounted yesterday as reports filtered in from stricken areas.

Some confusion arose over details of fatalities and a full list of names is not available.

But most of the deaths took place in Western Viti Levu, which took a savage mauling from wind and rain.

Refugee centres were operating in many parts of Fiji yesterday, giving food and shelter to those the hurricane drove from their homes.

In the Suva and Nausori districts, officials recorded more than 1500 homeless people.

CENTRES

There were 500 at Lautoka, 800 at Ba and more than 300 in the Navua area.

A spokesman said the Government knew at least 3000 people were homeless and accommodated in refugee centres.

"But there must be many more homeless than this," he said.

Figures were not available from such areas as Rotuma and the Yasawas, which got the full force of Bebe.

Suva escaped the type of beating the west suffered.

But 80 and 90 mph winds buffeted the capital throughout Tuesday night, with a maximum gust of 100 mph.

Officials in the city received no reports of major damage.

The hurricane uprooted trees, brought down telephone wires and power lines, and damaged buildings.

Most of the homeless from the city area lived in relatively flimsy structures.

Navua, 35 miles from Suva on Queens Road, was badly hit.

The full fury of Hurricane Bebe hit Lautoka and Ba and destroyed hundreds of homes.

The houses unroofed at Lautoka include the home of the Leader of the Opposition, Mr. Siddiq Koya.

He was not in the house at the time, but his family was.

SCHOOLS

Twisted roofing iron and timber and entire walls and roofs of buildings, some of which had been carried miles, littered both urban and rural areas after the storm.

Almost all schools suffered damage and one was destroyed.

Teidamu Indian School, which took the full blast of the wind, was swept out to sea. . . .

One family at Ba camped in a small washroom all night after their roof blew away.

"We are grateful we are alive," one of them said.

Ba was 5ft under water but no one was reported swept away.

Damage to crops cannot be estimated, according to the canegrowers' senior representative on the Sugar Advisory Council, Mr. Y. Subramaniam.

But he added that the storm wiped out large areas of cane, rice and other crops.

*Figure 10.26: **Fiji Times**, 26–27 October 1972*

Hurricane will cost us millions

Damage and losses from Hurricane Bebe will cost the Fiji economy millions of dollars.

At a news conference yesterday the Prime Minister, Ratu Sir Kamisese Mara, and the Minister of Finance, Mr. Charles Stinson, agreed that $2 million would be a conservative guess of the size of the hurricane bill.

Mr. Stinson said the cost would make an already tight Budget situation tighter still.

The cost of rebuilding the destroyed Navua Bridge could alone be about $750,000, he said.

The first attempts to establish sugar cane as a commercial crop were made near Suva, but the climate in this area was not as suitable as that on the western side of the island. A study of the climatic graphs for four towns on Viti Levu (figure 10.21) shows local variations in climate. Note the location of the four towns in figure 10.1, determine which are in major cane-growing provinces, and compare their temperature ranges and the amount and distribution of rainfall. Some idea of rainfall intensity can be obtained by dividing the average monthly rainfall by the number of wet days for that month. In what significant ways does the climate of the cane growing areas differ from that of Suva?

Further information about the climate can be gained from figures 10.22, 10.23 and 10.24, which represent the major types of vegetation—rainforest, grassland and mangroves.

The prevailing winds for Suva are south-east for each month of the year; however, Nadi receives south-east winds from April to December, and during January, February and March the winds are westerly. Refer to the Lautoka climatic graph in figure 10.21. (Lautoka is 29 kilometres from Nadi.) Suggest reasons for the west coast rainfall pattern, giving consideration to air masses and the mountainous nature of Viti Levu. The climatic graphs give no indication that Fiji also lies in the path of tropical cyclones or hurricanes. Refer to figures 10.25 and 10.26.

During the growing period the sugar plant needs constant and abundant (though not excessive) moisture and sunlight. (The 'dry' coasts have an average annual rainfall of 1775–2000 mm, the 'wet' coast averages 3550 mm.) A further advantage on the west coast is the cooler 'dry' season, which helps to develop a high sugar content in the cane stalk before harvesting—note the climate of the major sugar-growing province. The drier side of Viti Levu has other advantages; the native grasses are easily ploughed in when bringing new land under cultivation and the problem of drainage is less than on the 'wet' side.

The agricultural distribution map you constructed earlier from table 10.2 does not give a true picture of the location of commercial cane-growing areas. Sugar cane is usually grown on the level, undulating or hilly areas along the coast within a few kilometres of the ocean. Refer to figure 10.27.

Figure 10.27: Cane growing areas and sugar mills

In general, steep slopes, high elevation and mangrove areas are avoided. Refer to the map extract, figure 10.28, and to figure 10.29. On the map, locate the area covered by the aerial photograph. Which parts of the land have been cultivated and which have not? Denudation of the hills by heavy rainfall, as shown in figure 10.30, has resulted in alluvial flats along the river valleys, and these are well suited to cultivation.

However, less than a third of Fiji's total cane-growing area is on first-class soils. Sugar cane can be grown throughout Fiji, and growers of commercial crops seek optimum conditions wherever possible, weighing the advantages and disadvantages of a particular location in reaching their decision on where to cultivate. Thus other factors may encourage cultivation under less favourable soil or climatic conditions; for example, poorer soils that are close to mills may be used in preference to first-class soils further away.

The farmer's market for his cane is the raw sugar mill. Cane should be crushed within two days of cutting, if possible. Mills must therefore be large and efficient to handle the huge quantities of cane that are rushed to them during the harvest period.

Mills are located at Lautoka (capacity 600 000 tonnes), Ba (Rarawai Mill, 335 000 tonnes), and Rakiraki (Penang Mill, 95 000 tonnes) on Viti Levu, and Labasa (170 000 tonnes) on Vanua Levu. The Lautoka and Rarawai mills account for 70 per cent of the total output of raw sugar. Refer to figures 10.27 and 10.31; suggest reasons for the location of the mills. Now read the following description.

> The regional location of sugar mills is determined by those geographic factors, soil, climate and terrain, which define the areas where cane can be grown successfully. Mills must have large continuous supplies of cane and cane growers must have a mill nearby. Cane is too bulky, heavy and perishable to transport over great distances, although moderate distances are practicable if the transport is cheap, quick and sure.
>
> A. G. Lowndes, ed., *South Pacific Enterprise* (Sydney: Angus & Robertson, 1956), p. 120

The mills were operated by South Pacific Sugar Mills Ltd, a subsidiary of C.S.R., until 1973, when the Fiji Sugar Corporation took over after C.S.R. had sold its interest to the Fijian government.

Each farmer signs a contract with the mill, agreeing to deliver a set quota of cane. Sugar is a low-cost tropical product and the international market is highly competitive; therefore, for efficient operation the millers must regulate the amount of cane coming in to them to match the market requirement. To do this, they allocate each farmer a set quota of cane and a guaranteed minimum price per tonne. The sugar industry in Fiji involves approximately 15 000 cane contracts and a national basic allotment of 2 556 256 tonnes of cane. The farmer was guaranteed a minimum payment of $F7·87 per tonne of cane in 1972. Using this information, and assuming that each farmer has one contract, calculate the canegrowers' average gross income.

The actual price paid to the farmer is determined by the proceeds of sale. After selling the raw sugar for a particular season, the millers deduct certain expenses and then share the receipts on a proportional basis among the growers and themselves. Therefore, each grower probably receives more than your calculated figure, although the amount varies according to the price of sugar on the world market. The gross payment made to the farmer by the mill is not all profit. The grower has to pay for the cost of seed cane, fertiliser, harvesting, and transporting his cane to a delivery point.

The international market for sugar fluctuates under the influences of demand, productivity and political factors (what effects might this have on the Fijian economy?). The farmer has no control over the international sugar market, nor can he predict the variations in weather that may give him a bumper harvest or result in crop failure. Droughts in 1966 and 1967, and hurricane Bebe in 1972, resulted in lower sugar output.

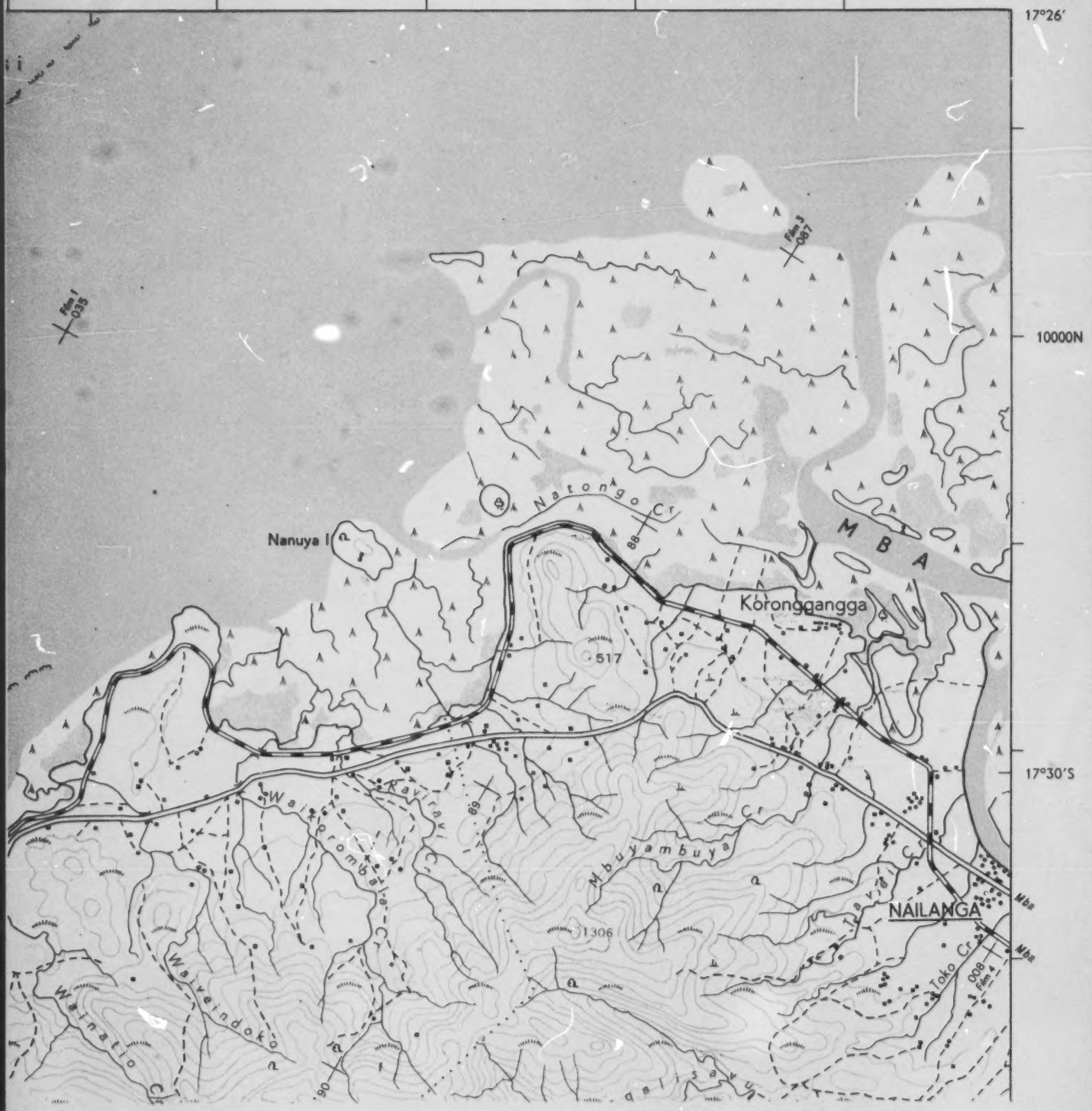


Figure 10.28: Map extract—Viti Levu, sheet 4, 1 : 50 000 ***(Reproduced with permission from the Ministry of Lands and Mineral Resources, Fiji)***

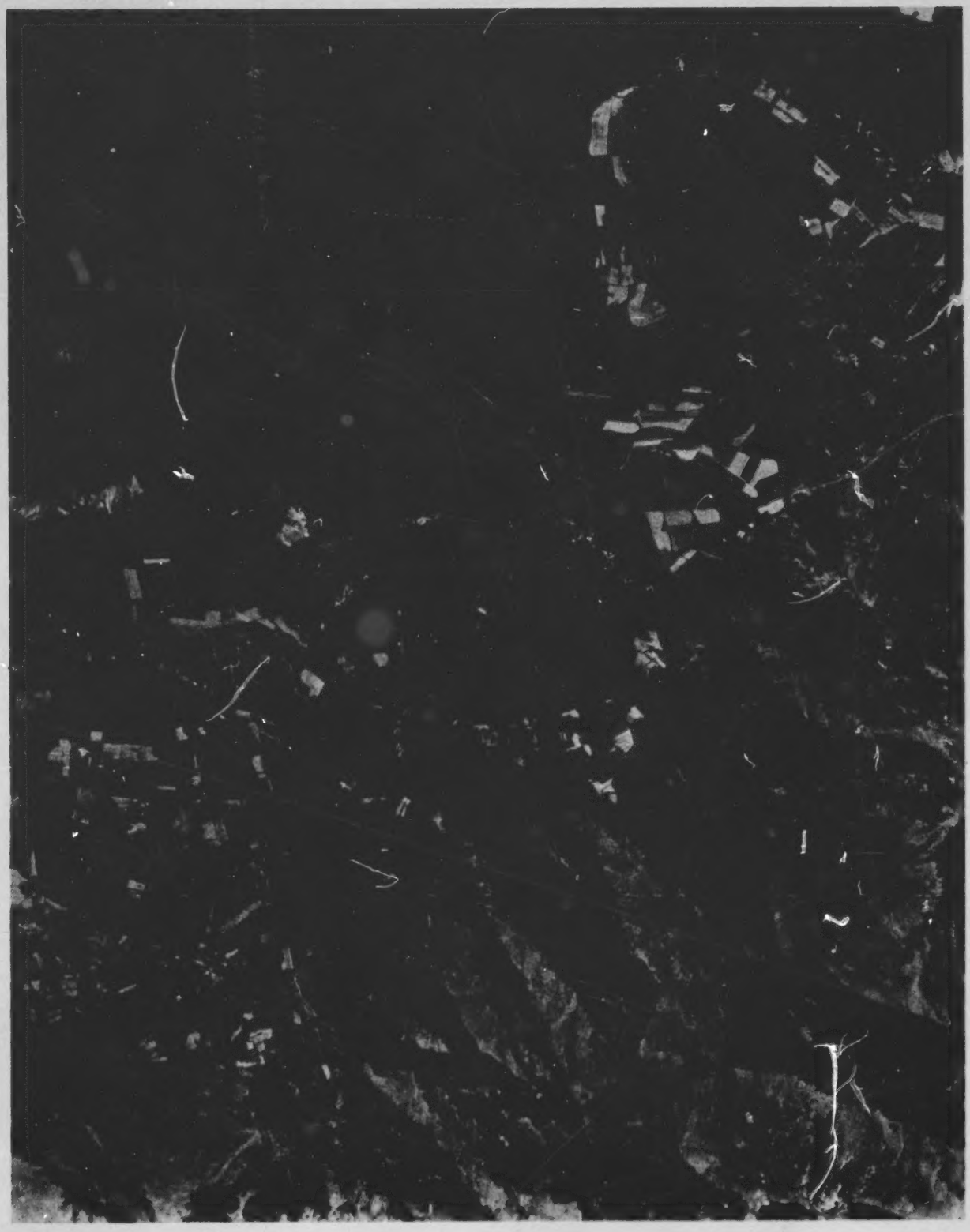


Figure 10.29: Vertical aerial photograph of a cane growing area on Viti Levu **(Reproduced with permission from the Ministry of Lands and Mineral Resources, Fiji)**

Figure 10.30: Denuded hills—the Nausori Highlands near Nadi

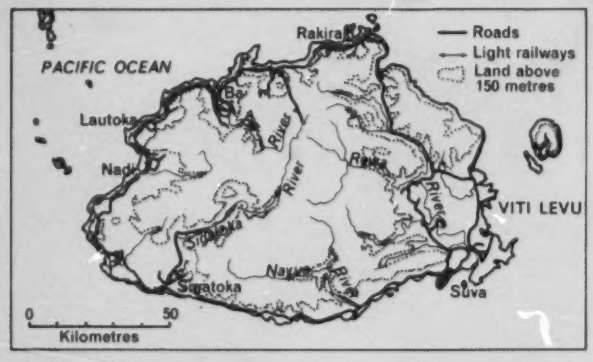


Figure 10.31

What factors could affect the international sugar market to result in (a) an increase, (b) a decrease in price? If a mill offered a high quota or price for cane, how could the farmer increase his output? How could the Fijian government help him to do this? If the world demand for cane declined, what forms of assistance could be given to the farmer? What risks does a farmer face with regard to his income for the following season?

The miller accepts delivery of cut stalks of cane, from which he manufactures and sells raw sugar, molasses and other profitable by-products. Since the local demand for sugar is not high, the millers must sell overseas on a world market and must therefore be assured of a regular supply of good-quality cane. They can assist the farmer in maintaining this supply by offering advice, experimenting with new cane varieties, providing fertilisers and advancing money to pay for harvesting. The money owing to the mill is deducted from the farmer's total payment for cane delivered.

The miller undertakes to transport the cane to the mill from specific points and has constructed a light railway for this purpose (figure 10.32). Motor vehicles are also used. Note the distribution of these railways in figure 10.31. How far do the tracks extend from Lautoka?

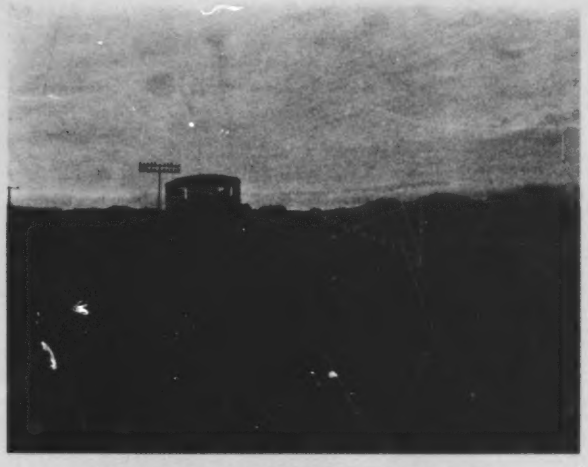


Figure 10.32: Diesel locomotive hauling cane

The provision of this transport system is of great benefit to the grower, for if a farmer had to deliver to the mill his costs would increase; also, without this service farmers further away from the mill would have greater costs than those nearer. Before reading the following description, try to think of ways in which the location of the mills and the transport system have influenced the distribution of cane growing in Fiji.

The mill tramline system, a light railway of 0·61 metres gauge, is the great artery of the cane producing area. It is located according to practicable grades, the distribution of the good cane lands and the geographical and historical facts which originally determined the location of the mill. Once established it largely determines the location of new farms and even townships, and it ties together and serves the whole cane growing area. . . .

It saves double handling of the cut cane, it helps longer hauls to be made more economically and evens out the value of cane farming land; it affects soils that are inclined to compact less than other methods and minimizes damage to cane stools and subsequent ratoon crops; it allows harvesting to continue when fields are wet and boggy and it reduces the growers' expenses. A disadvantage is the high capital cost to the mill owner.

South Pacific Enterprise, pp. 135–6

Over the years the tramline method has had a strong beneficial influence by stretching out to, and confining cane growing to, flatter, moister and less erodible land; in the long run such land gives higher average yields.

Since the local demand for sugar is low, it is uneconomical to establish a refinery in Fiji. Refineries are located close to the market for economy of distribution. Note that the sugar ports are located at Lautoka (figure 10.33), Ellington (near Rakiraki)

Figure 10.33: Vertical aerial photograph of Lautoka showing sugar mill and port facilities

and Malau (near Labasa). Ninety per cent of refined sugar for local use is imported from Australian refineries.

Although the sugar industry is dominated by Indians, there is now a tendency for more Fijians to show interest in growing cane commercially and to adapt to a money economy. Training schools have been established by the Fijian government.

However, future expansion of the sugar industry is limited and possibly unwise (why might this be so?). It is estimated that the total area under sugar cane will stabilise at 44 517 hectares in 1975. Fijians thus have little opportunity to establish themselves as canegrowers. What could happen when the leases of N.L.T.B. land held by Indians (figure 10.15) run out?

Fijians and Indians are being encouraged to grow other cash crops such as cacao (figure 10.34), tobacco (figure 10.35) and vegetables. The production of cash crops other than sugar cane can assist in building up more diversified exports and reducing imports.

Figure 10.34: Cacao, Naitasiri Province

Figure 10.35: Tobacco, Nadroga and Navosa Province

Figure 10.36: Duty-free shops in Lautoka

Figure 10.37: A Pan Am jumbo jet at Nadi International Airport

One other resource that can be developed still further is tourism (figures 10.36 and 10.37). Tourists spent $F26 million in Fiji in 1970, but much of this would be needed to pay for the imports of watches, cameras and transistor radios that are sold duty free to tourists. Tourism accounts for only 3·4 per cent of the total value of production, which is small compared to sugar (20 per cent). However, the growth potential of tourism is considerable, and the tourist industry provides opportunities for Fijians in many fields such as motels, transport, food production and local craft goods.

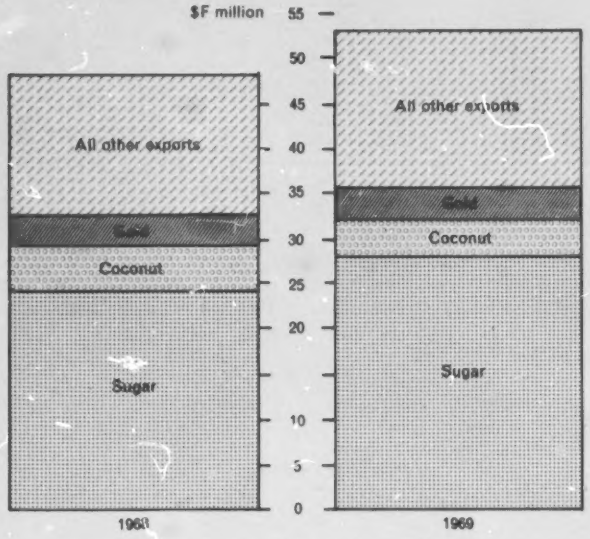


Figure 10.38: Fiji—principal exports, 1971

Sugar is the dominant export of Fiji (figure 10.38) and its production directly benefits many people (figure 10.39). It is also of benefit to those not directly associated with the sugar industry by bringing in foreign revenue, through payment of

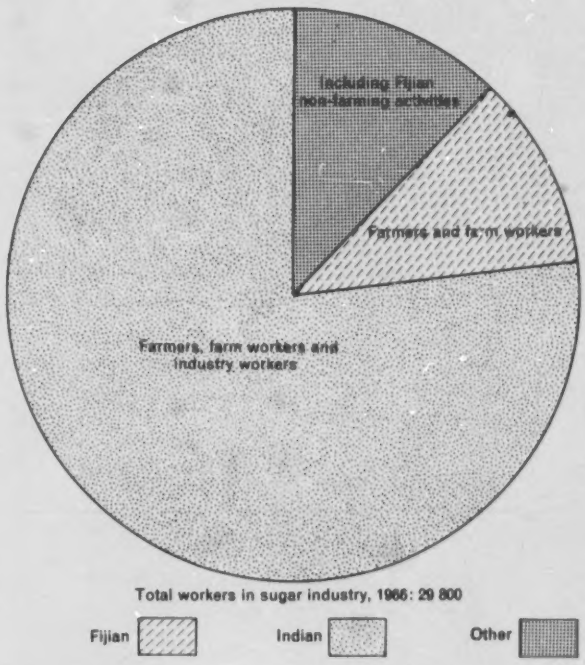


Figure 10.39: Structure of the sugar industry workforce, 1966

taxes to the government, and as a result of the money that the mills, mill employees and farmers spend on goods and services in towns such as Lautoka.

In this study of sugar production you should have noticed similarities to some types of farming that you have studied and contrasts with other types. You should also have seen that in Fiji there are variations in the way different farmers produce sugar. Describe these differences within Fiji, and between farming in Fiji and other types of farming elsewhere.

11

Food production in North America

North America includes the countries of Canada and the United States, and is an area of the earth's surface with wide variations in the types of people (see study 5 of Level Two, *Space in Change*), relief, soils and climate—consult your atlas and see what information it gives on each of these aspects.

We will be looking at two areas on the eastern side of the continent: the St Lawrence Lowlands of Canada, and the state of Pennsylvania in the U.S.A.

Figure 11.1: North America

So far in this book, our main approach in trying to understand methods of food production has been to examine particular farms or villages. In this study, although we will still take the opportunity of looking at some individual farms, food production in larger areas will be examined intensively, through the use of comprehensive statistics, detailed description and smaller-scale maps.

The St Lawrence Lowlands

The St Lawrence Lowlands of Canada stretch along the St Lawrence River from its estuary south-west to the peninsula between Lake Huron and Lake Erie (figure 11.3). This area lies within the provinces of Ontario and Quebec and comprises almost all the farming land of the two provinces.

Figure 11.2 shows the types and relative value of agricultural production in Quebec and Ontario. How does the food production of the two provinces differ?

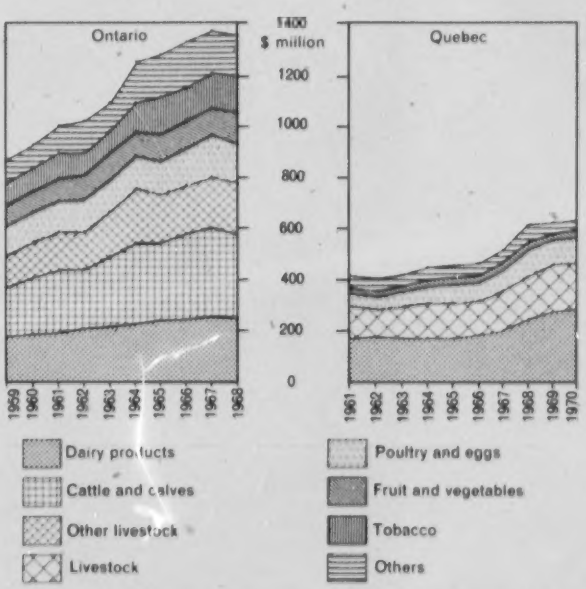


Figure 11.2: Cumulative farm cash receipts from sale of farm products, Ontario and Quebec

Figures 11.4–11.11 and 11.12–11.18 show in greater detail the distribution of different types of agricultural production in Quebec and Ontario respectively. Do these maps reveal any high concentrations of particular products?

Figure 11.3: The St Lawrence Lowlands

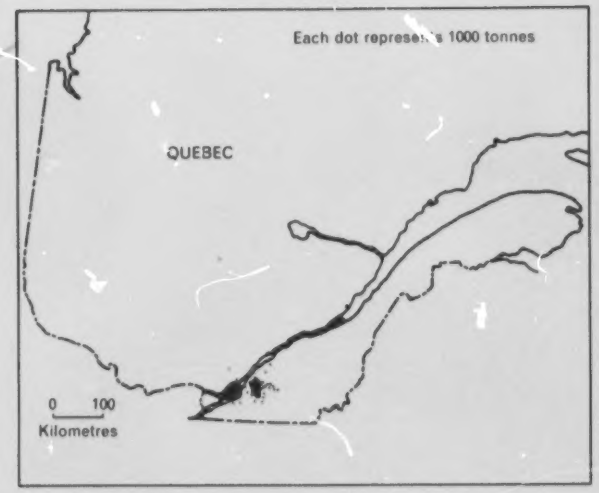


Figure 11.4: Quebec—sugar beet production, 1972

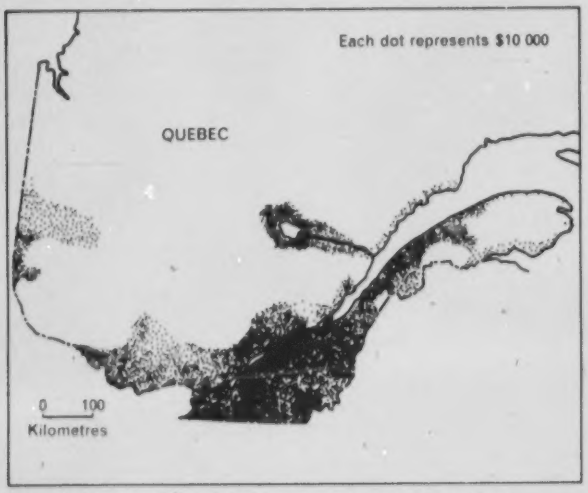


Figure 11.5: Quebec—value of cattle sold, 1972

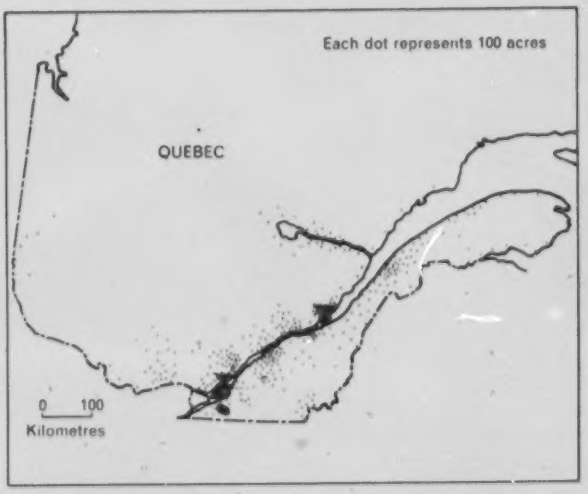


Figure 11.6: Quebec—area under potatoes, 1972

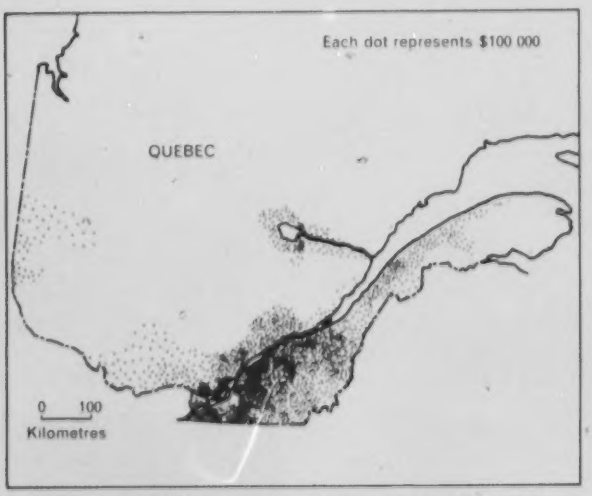


Figure 11.7: Quebec—value of dairy production, 1972

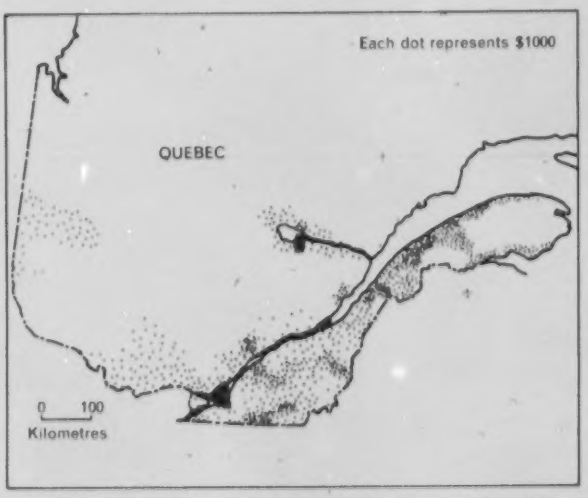


Figure 11.8: Quebec—value of sheep products sold, 1972

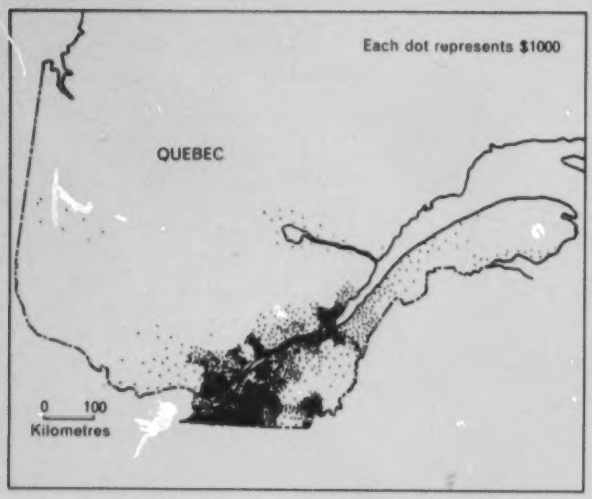


Figure 11.9: Quebec—value of fruit production, 1972

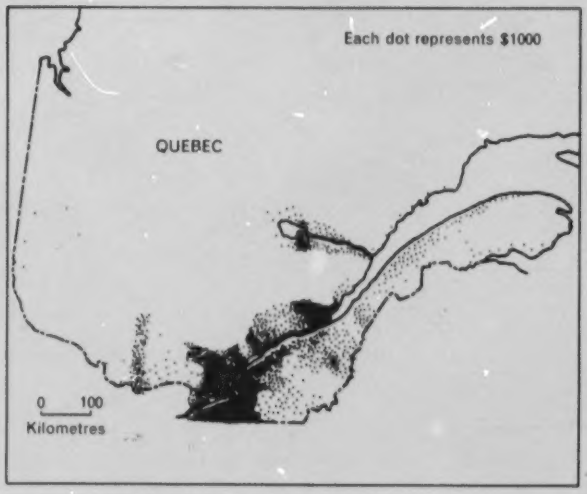


Figure 11.10: Quebec—value of vegetable production, 1972

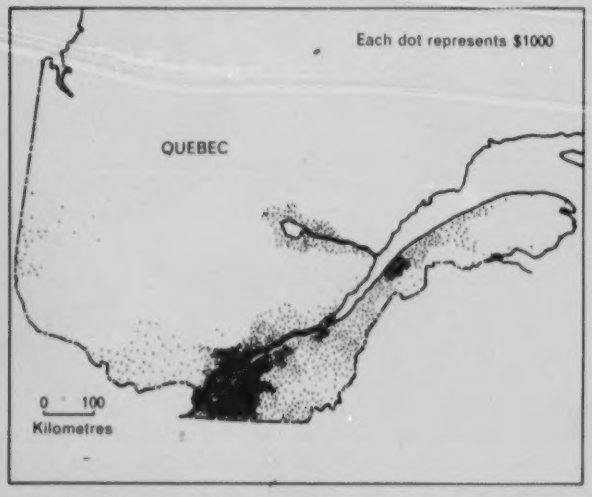


Figure 11.11: Quebec—value of oat production, 1972

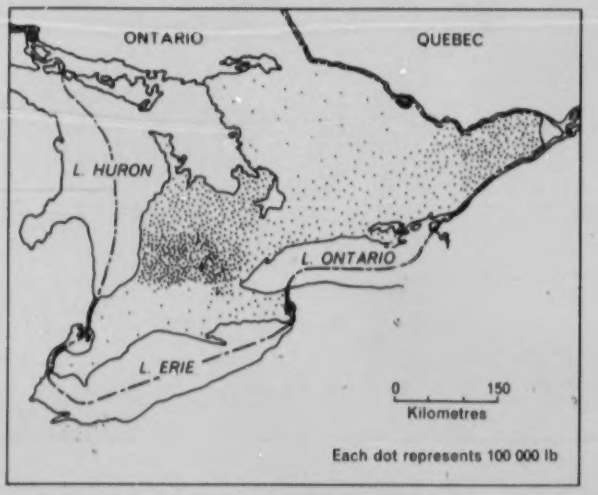


Figure 11.12: Ontario—creamery butter production, 1970

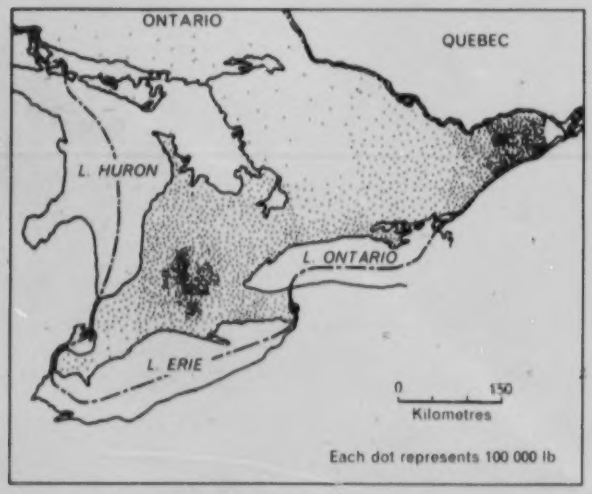


Figure 11.13: Ontario—milk production, 1970

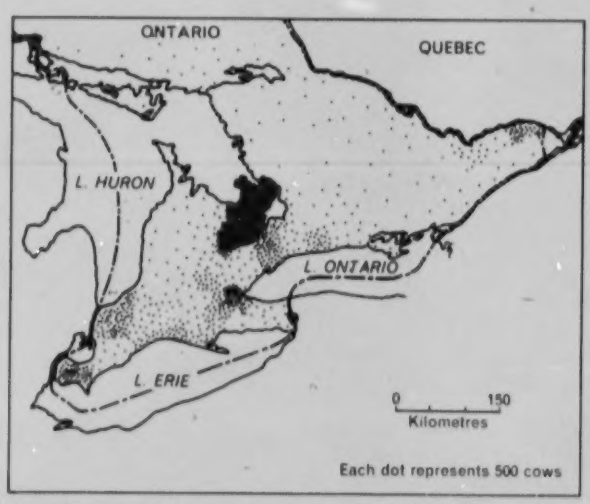


Figure 11.14: Ontario—numbers of milk cows, 1970

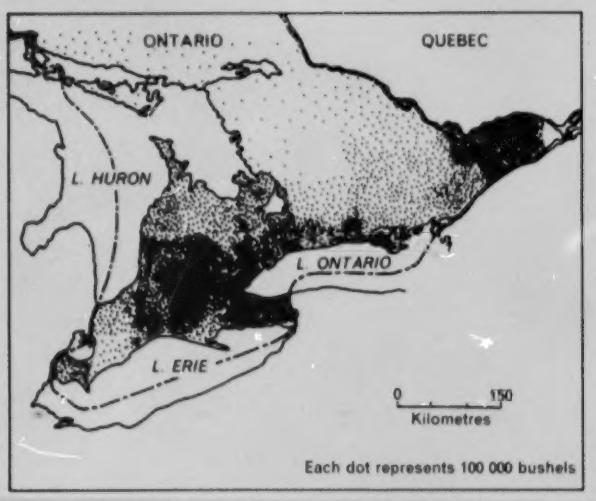


Figure 11.15: Ontario—potato production, 1970

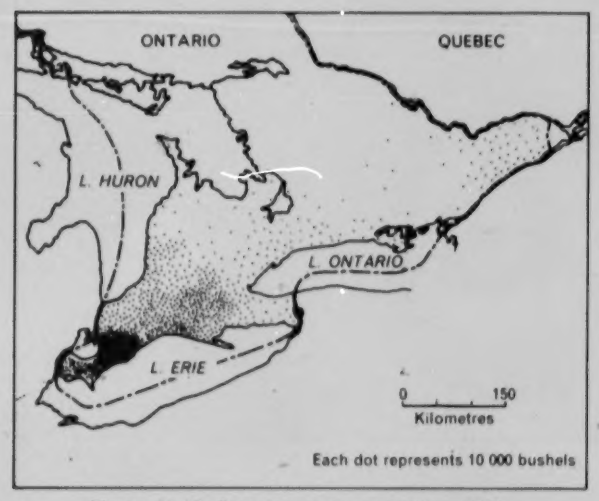


Figure 11.16: Ontario—corn production, 1970

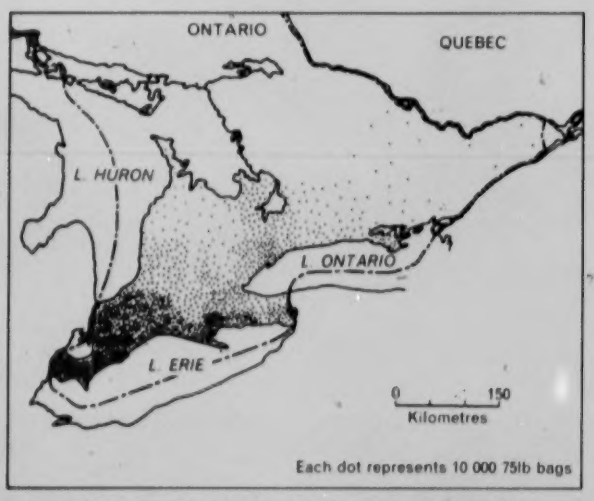


Figure 11.17: Ontario—wheat production, 1970

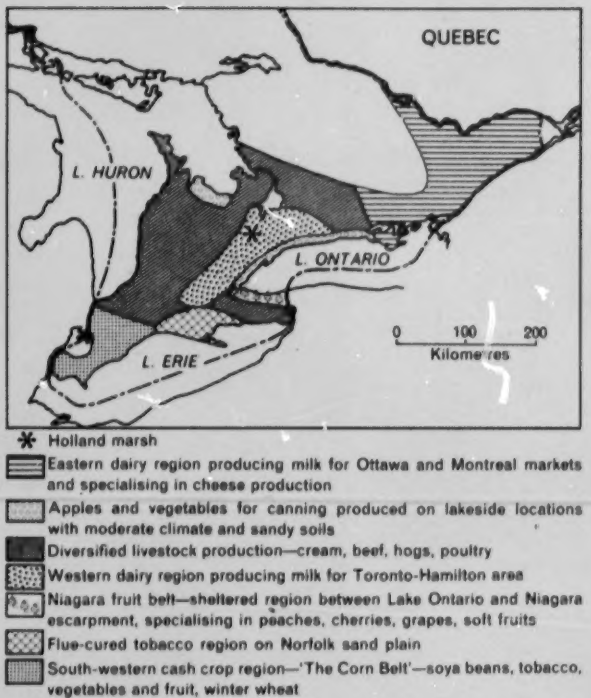

QUEBEC
L. HURON
L. ONTARIO
L. ERIE
0 100 200
Kilometres
* Holland marsh
Eastern dairy region producing milk for Ottawa and Montreal markets and specialising in cheese production
Apples and vegetables for canning produced on lakeside locations with moderate climate and sandy soils
Diversified livestock production—cream, beef, hogs, poultry
Western dairy region producing milk for Toronto-Hamilton area
Niagara fruit belt—sheltered region between Lake Ontario and Niagara escarpment, specialising in peaches, cherries, grapes, soft fruits
Flue-cured tobacco region on Norfolk sand plain
South-western cash crop region—'The Corn Belt'—soya beans, tobacco, vegetables and fruit, winter wheat

Figure 11.18: Agriculture in southern Ontario. Does this generalised map successfully sum up the particular maps in figures 11.12–11.17?

To find out why these concentrations occur—why farmers of a particular type have chosen to locate in a particular area—you need a great deal of information about the farmers' intentions. But you can use other sources of information that give clues to why farmers find certain areas more suited to some types of production than others.

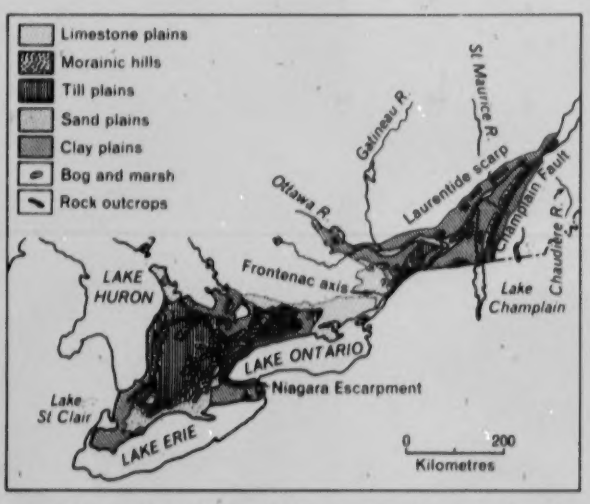


Figure 11.19: Landforms of the Great Lakes–St Lawrence Lowlands. After G. S. Tomkins, T. L. Hills and T. R. Weir, A Regional Geography of North America (Toronto: Gage, 1970)

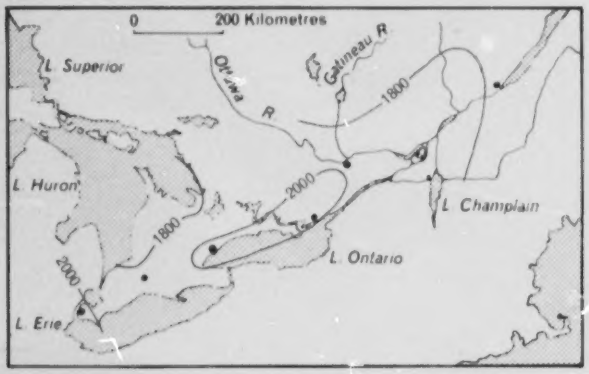


Figure 11.20: Mean annual total hours of bright sunshine (after Tomkins, Hills and Weir)

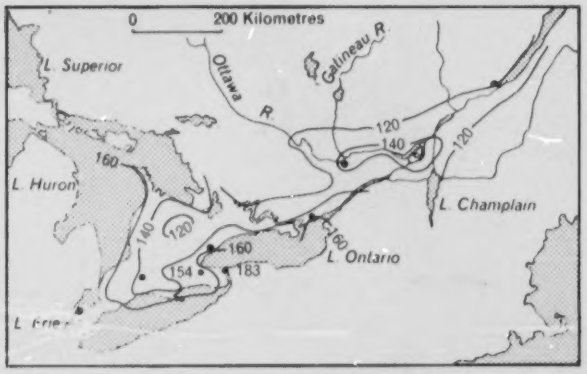


Figure 11.21: Mean annual frost-free period (days) (after Tomkins, Hills and Weir)

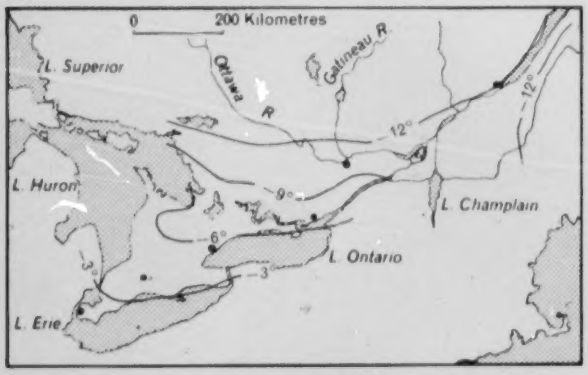


Figure 11.22: Mean daily temperature, January (°C) (after Tomkins, Hills and Weir)

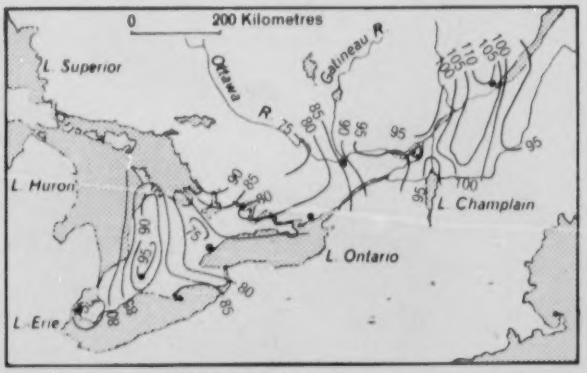


Figure 11.23: Mean annual total precipitation (mm) (after Tomkins, Hills and Weir)

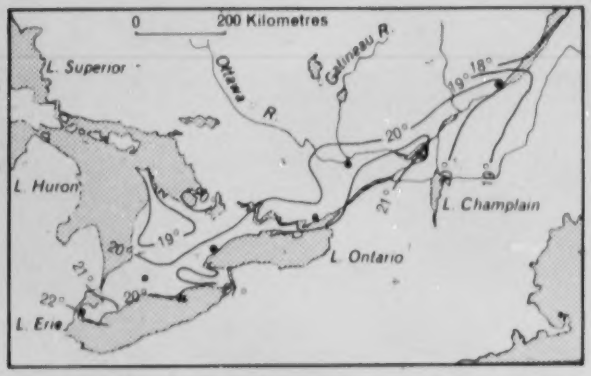


Figure 11.24: Mean daily temperature, July (°C) (after Tomkins, Hills and Weir)

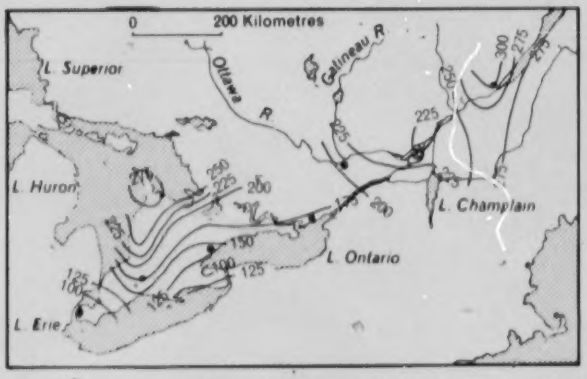


Figure 11.25: Mean annual total snowfall (mm) (after Tomkins, Hills and Weir)

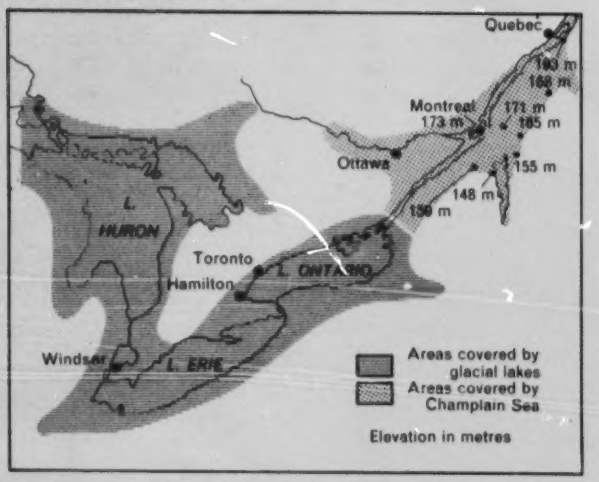


Figure 11.26: Area affected by glacial lakes and marine invasion during and immediately following the Ice Age. Note the elevation of the Champlain Sea beaches. What types of soils would be found as a result of the inundation of this area? (after Tomkins, Hills and Weir)

Figure 11.27: Metropolitan areas (numbers give populations in thousands)

Figures 11.19–11.27 show details of the relief, climate and distribution of major urban centres. Examine them carefully. Do they give you any clues to why farmers produce certain types of food in particular areas?

Of course, farmers do not always grow food in the most favourable locations. Every farmer would want to produce his crops and animals close to the market and thus save transport costs, to receive adequate, reliable rainfall, and to have soils suitable for his type of farming. But many farms receive inadequate or unreliable rainfall, have poor soils, and may be located a long way from where their produce is sold. How does this happen?

Think of two farmers in an area of flat farming land (figure 11.28). They have just bought their farms and are trying to decide how they will use the land. Will they grow vegetables or keep dairy cows?

Because farmer A was closer to the city than farmer B he could only afford to buy 25 hectares, while B could afford to buy 75 hectares for the same price, $25 000. Farmer A can produce, let's say, 50 tonnes of vegetables from his land, which he can sell for $400 per tonne. It would cost him $10 per tonne per kilometre to transport the vegetables to market. Farmer B could produce 150 tonnes of vegetables from his larger area of land, but he decides not to grow vegetables. Why can't he afford to do so? What sort of agricultural production does farmer B have to decide on to be able to make a profit? (This problem is very closely related to the situation examined in study 3 of this book.)

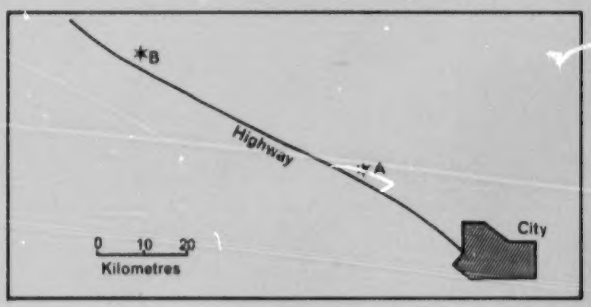


Figure 11.28

Two of the most intensive farming areas in the St Lawrence Lowlands are the plains around Montreal and the Niagara fruit belt (figure 11.18).

The Montreal Plain*

A brief reference to two farms will illustrate the variety and richness of farming in the Montreal Plain and will also show how agriculture has been adapted to soil and other local conditions. One of these farms is located north of Montreal in a very flat area where the soil consists of clay and sand. The farm comprises 35·2 hectares, which is small for a region where the average farm size is 50 hectares. These 35·2 hectares are composed of 28·7 hectares of improved land and 6·5 hectares of unimproved land. The improved land is used as shown in table 11.1.

Table 11.1: Use of improved land

Use	Area (hectares)
Cigar (air-cured) tobacco	1·2
Oats	8·1
Clover	8·1
Timothy hay	4·6
Turnips	0·5
Permanent pasture	5·5
Vegetable garden, fruit trees, buildings	0·7

A system of crop rotation is used, employing the following cycle: oats, clover, timothy hay, tobacco. The farmer keeps 11 milk cows, 5 heifers, 4 calves, 7 sows, 65 pigs, 193 broilers and 180 hens. His total revenue in a recent year was $10 504, which included $1107 from tobacco, $6529 from hogs, and

* This section slightly modified from G. S. Tomkins, T. L. Hills and T. R. Weir, *A Regional Geography of North America* (Toronto: Gage, 1970), pp. 148–9.

$1084 from cream. This mixed farm derives a large revenue from tobacco (considering the small area involved), a great deal from hogs, and a considerable amount from dairy produce.

Another mixed farm, in which dairying is the chief source of income, is that owned by Mr Henri Brault near Ste Martine, in Chateauguay County, about 30 kilometres south-west of Montreal in the heart of the richest farming land in the province of Quebec.

Mr Brault's farm is located in flat, open country and is organised in the typical French-Canadian long-lot pattern. The house, barn and other buildings are located near the side of a main road and the fields extend back from the road in long, narrow strips. Study figure 11.29. Together with a fifth field not shown on this map, and a second farm nearby, Mr Brault owns 91 hectares. These are measured in *arpents*, a French-Canadian measurement. The total area noted in figure 11.29 includes the fifth field of the main farm.

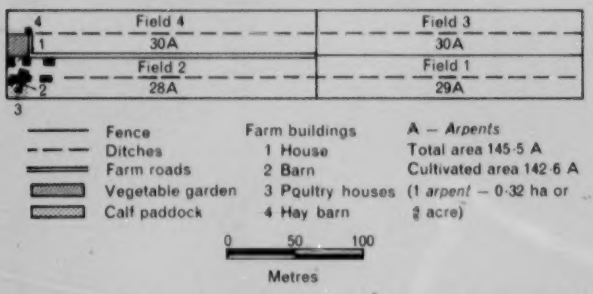


Figure 11.29: Four of the five fields of the Brault farm (after Tomkins, Hills and Weir)

The soil consists of the heavy Rideau clay derived from the Champlain Sea sediments (figure 11.26). Although it is rich, its nature and the flatness of the land provide a serious drainage problem. To meet this problem, deep ditches have been dug around the farm. There is also a central ditch down each field, along with many secondary ditches. The Richard system of ploughing creates many furrows that drain from one to the other and so into the ditches. By such methods, along with crop rotation, and the use of fertilisers and machinery, Mr Brault has doubled his crop yields in recent years. His crop system is designed to meet the needs of the fine dairy herd that is his chief source of income. Grass, clover and alfalfa are sown for summer pasture and to produce ensilage and hay for winter feed. The large tower-like silo and barn are used to store this feed during the six months or more when the cattle must be kept indoors. Indian corn is also grown for this purpose.

Mr Brault raises a number of cash crops. These include oats and barley sold for seed, sweet corn, flax, peas and beans. The vegetables mentioned are sold to a local cannery. The development of frost-resistant hybrids permits corn to be grown here, although the growing season rarely exceeds 150 days.

The dairy herd consists of 26 Holstein cows. Mr Brault sells an average of 80 000 litres of milk each year, most of it in Montreal. The cattle are milked by machine in a modern, well-ventilated barn. It also has a mechanical manure remover which transports the manure to a place in the yard from where it can be distributed to the fields. A pipeline carries milk from the machines directly into large milk containers in the dairy. Automatic drinking cups are available to the animals, water being pumped electrically from the main well under the house. Other machinery includes two tractors, a truck, a car, a binder, a mower, a hay baler, a threshing machine, and a vertical blower (for blowing corn and grass silage into the silos). Each spring, Mr Brault buys 600 day-old chicks and 200 turkey chicks from a local hatchery. The chickens are raised to be sold as broilers (at ten weeks) and to produce eggs. The turkeys mature in time for the Thanksgiving and Christmas markets.

Two problems facing farmers on the Montreal Plain relate to urban expansion and climate. This is illustrated by figure 11.30 showing the fantastic postwar growth of Montreal. Mr Brault's farm, only 30 kilometres from the city, has been in the path of this expansion. Hundreds of new homes have been built near Ste Martine in recent years. In 1956, it was estimated that by 1980 more than 2500 square kilometres of land in the Montreal Plain would be removed from farm production.

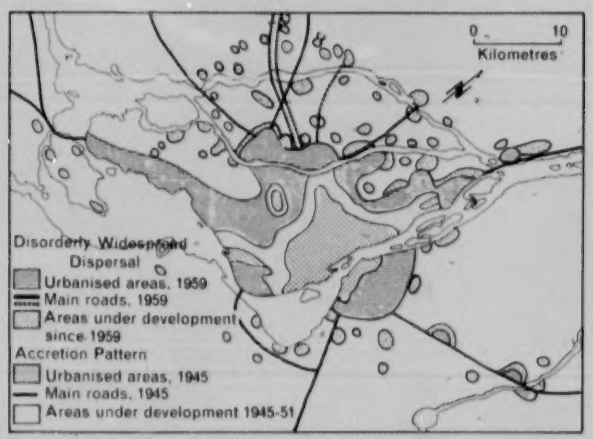


Figure 11.30: Urban growth in Montreal from 1945 to 1950 and since 1959 (after Tomkins, Hills and Weir)

A second problem facing farmers in this subregion relates to the provision of winter feed for the cattle, which must be kept indoors for about six months each year. In one year, for example, the animals could not be put out to pasture until 20 May. An unusually long and cold winter was followed by a wet spring during which the ground

was too soggy for grazing or for sowing crops. Sowing was delayed until 10 June. The short summers can be very hot and humid, although droughts are not unknown. In 1955, Mr Brault reported nearly sixty consecutive days without rain.

The Niagara fruit belt

The Niagara fruit belt's importance in Canadian fruit production is shown in table 11.2.

Table 11.2: Niagara fruit belt—percentage of Canadian fruit production by type

Fruit type	Percentage
Peach	75
Sweet cherry	88
Sour cherry	76
Pear	76
Plum	89

Figure 11.31 shows an area along the coast of Lake Ontario around the town of Grimsby. The relief clearly divides the area into two sections. How does the agricultural land use of these two sections differ? Can you think of reasons why this happens? (Refer back to the previous maps for assistance.)

Examine figure 11.32. How does fruit production in other orchard areas of Ontario differ from that in the Niagara fruit belt, in terms of the types of fruit? Can you suggest reasons for these differences?

In 1921 in Ontario, the area under fruit was 72 000 hectares; in 1966 the figure was less than 28 000 hectares. Why do you think this was happening? What are farmers doing in response to this?

During the same period of time the average size of orchards increased from 1 to 4 hectares. There are now fewer farms, but they are more specialised, and as a result yields have increased.

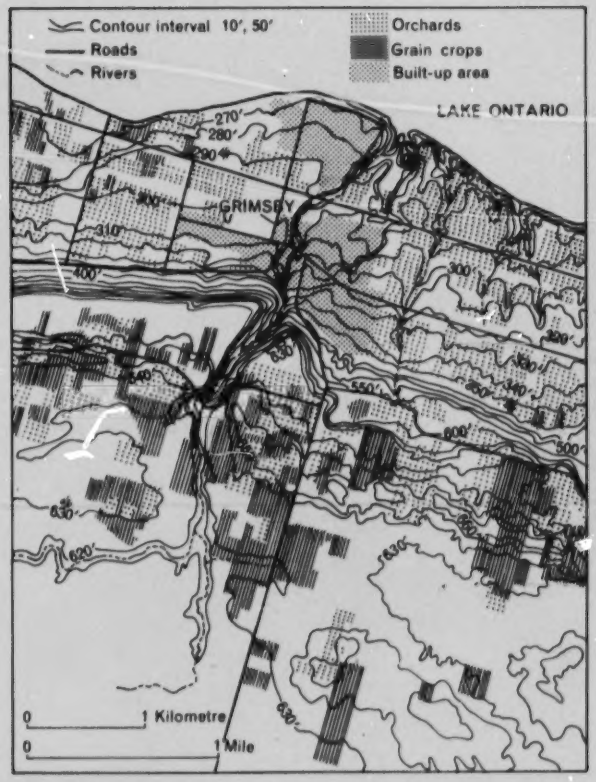


Figure 11.31: Relief and land use in the Grimsby area (contours in feet)

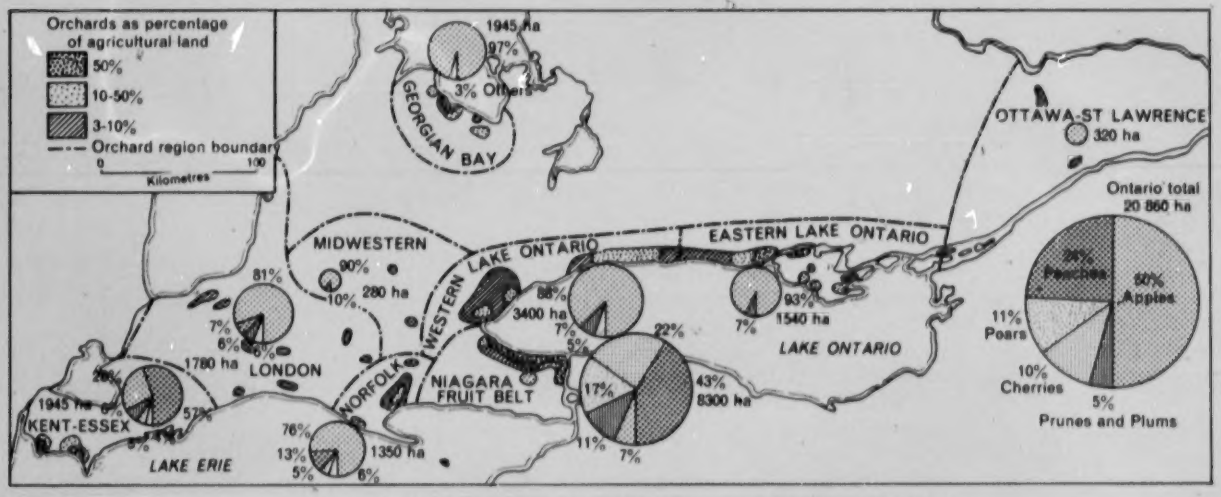


Figure 11.32: Orchard regions of Ontario (after Tomkins, Hills and Weir)

Pennsylvania

One of the problems of food production that was mentioned briefly in relation to the St Lawrence Lowlands was the loss of good agricultural land to other uses. In Pennsylvania, further south, this problem has been investigated by the Governor's Committee for the Preservation of Agricultural Land, which was appointed in 1967 'to make a study of the factors responsible for creating a potential deficit of agricultural land, to define the type of land areas that should be preserved for agricultural uses, and to prepare recommendations for an action programme to preserve agricultural land used in the production of food and fibre'.

In December 1969, the committee submitted its final report and recommendations. The introduction to the report ran as follows:

Nearly one-half of Pennsylvania's farmland has gone out of food production since the turn of the century. This includes 420,000 acres of some of Pennsylvania's best agricultural land which has been converted to nonagricultural uses in the past 10 years; an average of 115 acres of agricultural land, including 99 acres of cropland, has been transferred to other uses each day. This pattern has been accelerating and is likely to continue.

Pennsylvania, with its 28·8 million acres of land, appears to have enough acreage to satisfy any future needs. A closer look reveals that this will not be the case at the present rate of land conversion. About 25 percent of total land, or 8 million acres, is currently being farmed. Urbanization has claimed 13 percent, or 3·6 million acres, and forest land covers 62 percent, or 17 million acres.

This would seem to indicate that 87 percent of the state remains rural and potentially agricultural. This is far from the truth as is vividly illustrated by checking the Generalized Agricultural Land Capability Map prepared at the request of this committee by the State Planning Board from data provided by the United States Department of Agriculture Soil Conservation Service [figure 11.33]. A comparison may also be made of the recently completed inventory of land use by agricultural land capability classes with the inventory of 1958, as prepared by the Soil Conservation Service.

Agricultural production, to be economically feasible for both the producer and the consumer, must occur on good soil under favorable weather conditions. Of the 8 million acres of farmland in Pennsylvania, less than 40 percent is classified 'good' for agricultural purposes on the Generalized Agricultural Land Capability Map. Moreover, much of this 'good' soil is also often interspersed with less fertile soils and converted to other uses when less desirable soils are developed for nonagricultural purposes.

In our fast-moving society there are mutual interests between urban and rural people in addition to the production of food and fiber. All people are dependent upon soil, plants, animals, water and air for their existence. The interdependence of these resources is vital to the continued existence of our population. Unplanned urban growth gives little thought to the varied uses and values of land and the need for open areas for the well-being of our society.

Concentration of population in our cities has spawned a complexity of problems that challenges the minds of men. The transition of prime agricultural or forest land adjacent to population centers may have worked out satisfactorily in the short term, but the final results have been neither economically sound nor sociologically advantageous to agriculture or congested cities and the surrounding suburbs.

Today we have rural dwellers in increasing numbers seeking jobs in cities as a result of sagging agricultural income. Conversely, we have countless city dwellers flocking to the nearest 'open space' or rural area on weekends to escape the uncomfortable and crowded urban complex. Neither the city dweller nor the relocated farmer enjoys the full benefit of a balanced environment; at the same time, prime agricultural land continues to be devoured by unchecked urban sprawl.

Pennsylvania is especially fortunate in its abundance of natural resources. Chief among these are our soils which are where we find them and cannot be moved economically to other convenient locations. Once land which supports agriculture and agribusiness (Pennsylvania's second largest industry) goes into nonagricultural use, it will for the most part be forever unavailable to the people of Pennsylvania for the production of food and fiber.

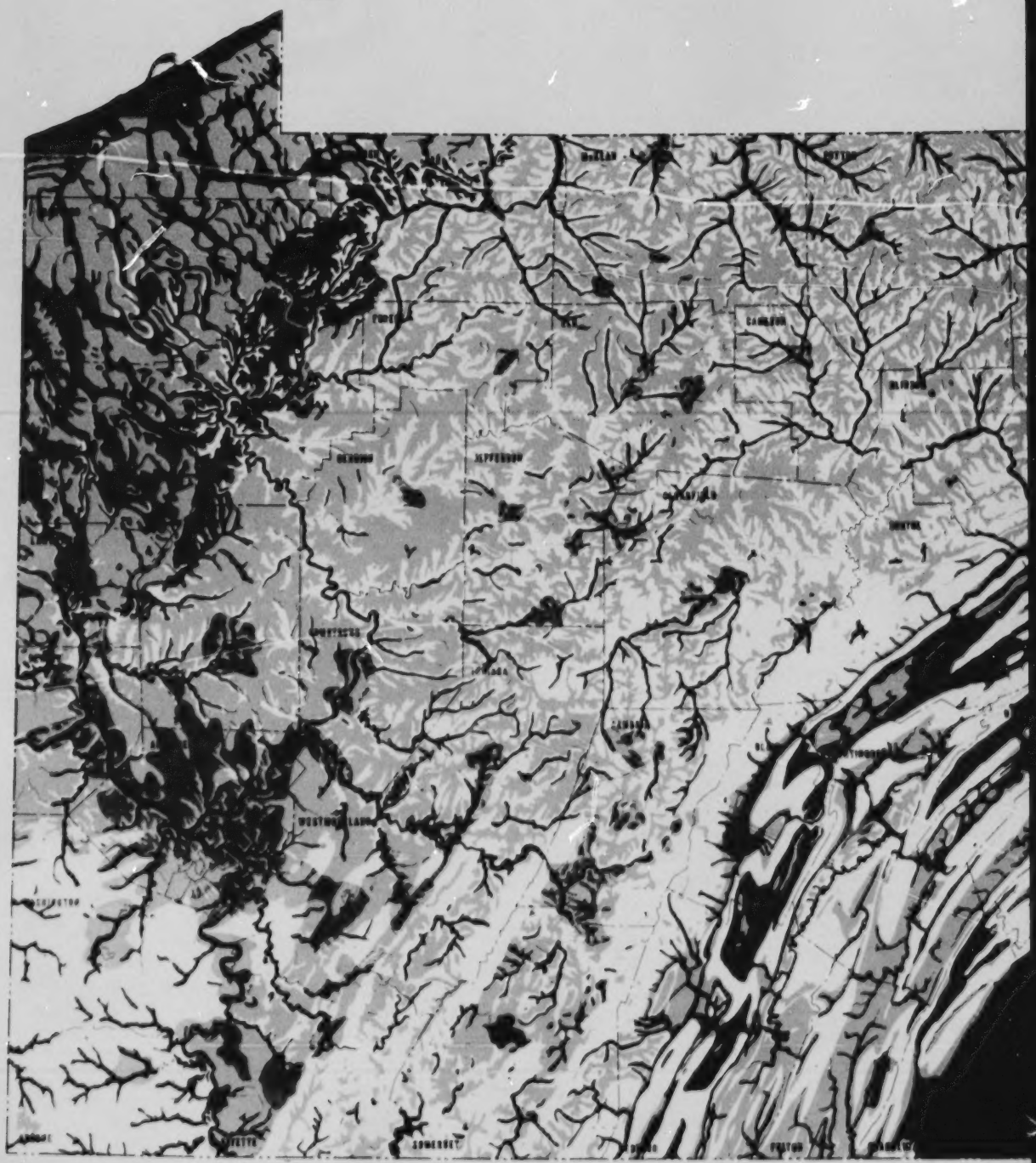
Summary of agricultural land use by land capability classes*
(million acres)†

Land classes	Cropland		Pasture		Woodland		Other‡		Total	
	1958	1968	1958	1968	1958	1968	1958	1968	1958	1968
I,II (good)	3·0	2·6	0·5	0·4	1·8	2·1	0·6	0·5	5·9	5·6
III (fair)	2·2	2·0	0·7	0·5	1·9	2·6	0·8	0·5	5·7	5·6
IV–VIII (poor)	1·7	1·6	0·9	0·8	10·8	11·4	1·1	0·7	14·7	14·5
Total	6·9	6·2	2·1	1·8	14·6	16·1	2·5	1·7	26·2	25·7

*The inventoried acreage did not include Federal land (except cropland), urban and built-up areas and certain water areas and therefore does not equal the state total of 28·8 million acres.

†All numbers rounded off to nearest 100,000 acres.

‡Other land including farmsteads, lanes, wasteland, rural nonfarm residential sites, churches, schools, cemeteries, etc.



DATA PROVIDED BY THE U.S. DEPT. OF AGRICULTURE SOIL CONSERVATION SERVICE FOR THE GOVERNOR'S COMMITTEE FOR THE PRESERVATION OF AGRICULTURAL LAND AND THE STATE SOIL AND WATER CONSERVATION COMMISSION

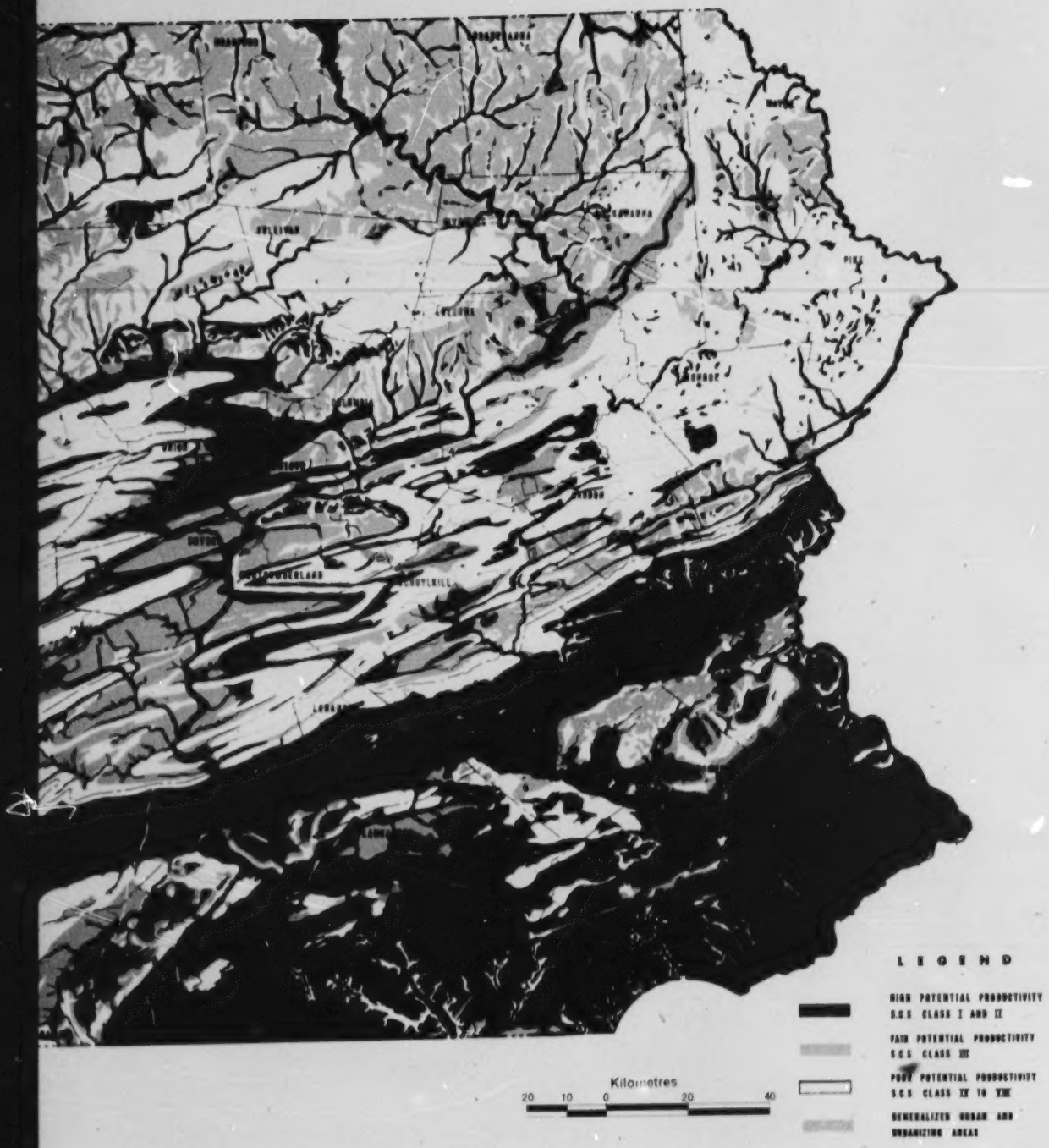


Figure 11.33: Pennsylvania—generalised agricultural land capability (Pennsylvania State Planning Board, 1969)

Most of the agricultural land that is taken out of food production occurs as a result of two groups of factors at work:

1. Many farmers find it more profitable to obtain off-farm employment than to continue farming. As a result of this trend, many farmers curtail farming operations while they continue living on the farm. The better land is usually incorporated into the farming operations of other farmers of the area and the poorer land becomes idle or slowly reverts back to forest land.
2. The second group of factors removing productive land from agricultural use is transference to nonagricultural use. This happens through land purchase at a price above its value for food or fiber production or through the use of eminent domain.

Our problem, therefore, is to devise measures to slow down the shift of good agricultural land to nonagricultural purposes and to encourage the use of less productive, poorly adapted agricultural land for nonagricultural purposes. The overall purpose of these measures would be to foster the most economic use of our varied land resources for the total welfare of all the citizens of the Commonwealth. In this report, the committee addresses itself to specific recommendations for the solution of this pressing problem.

This introduction reveals a number of problems and emphasises the *interdependence* between farming and urban communities and resources. The report goes on:

Pennsylvania's agricultural land and its related agribusiness complex produce and distribute high-quality food and fiber for the state's consumers at a reasonable cost. The wide variety of soil and climatic conditions in Pennsylvania provides for a correspondingly wide variety of fruit, vegetables, grain, animal products, and other life-sustaining necessities for our consumers. Knowledgeable management, adundant yields and close proximity to markets assure Pennsylvanians of an adequate and economic supply.

Where are the markets? Examine figure 11.33, which shows the location of generalised urban and urbanising areas in Pennsylvania. Figure 11.34 maps the state's major landform regions. On which types of land are the urban areas located? Do you agree with the committee's comments in the introduction to the report?

Examine figure 11.35. What kind of production area is shown around the major cities? What type of land use do you think this would be? There are very close similarities between this map and the map of generalised agricultural land capability (figure 11.33). What sorts of agricultural production are found in the various capability classes? Compare these two maps with an atlas map of the U.S.A.'s relief and with the study of the early settlement of the U.S.A. in Level Two, *Space in Change*. What problems were faced by the early settlers in Pennsylvania? (Figure 11.34 may also help you to answer this question.)

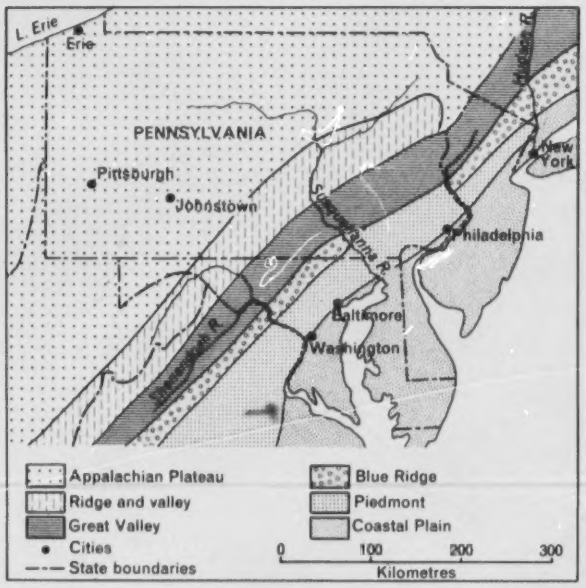


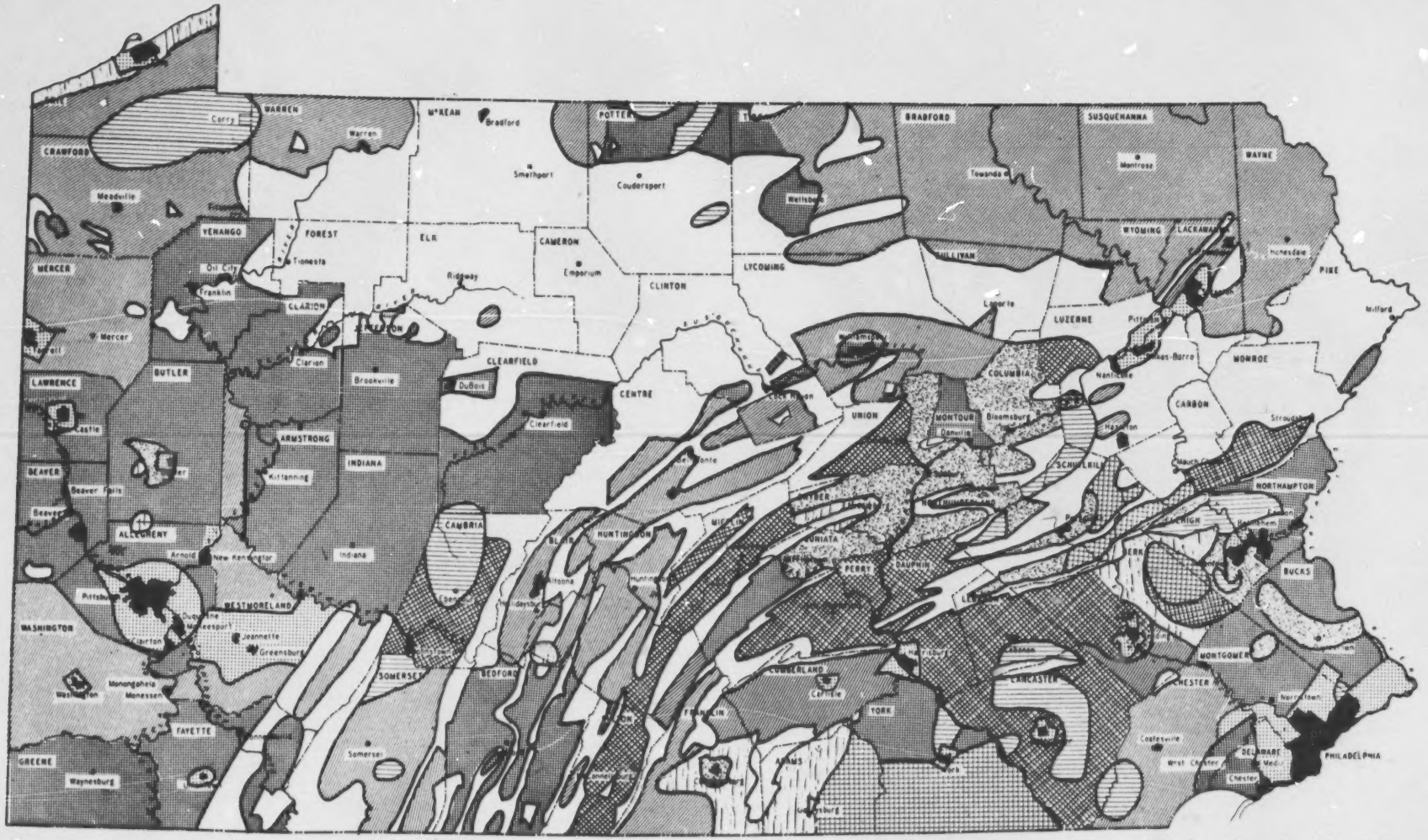
Figure 11.34: Landform regions of Pennsylvania

Two of this state's most important products are eggs and milk. Pennsylvania ranks fifth among all American states in production of these commodities. In broilers (chickens raised for meat), and in cattle slaughtered, Pennsylvania ranks twelfth.

Figures 11.36–11.39 show the distribution of these animal farming types in Pennsylvania. Which types are more concentrated than others? Suggest reasons to account for this. Compare these maps with figure 11.34, the map of landform regions. You can see that the series of mountain ranges in this area, the Appalachians, can be divided into several distinct regions from east to west. The first region is called the Piedmont. (Can you remember from Level Two the derivation of this name?)

Figure 11.40 shows an area of farming land in Lancaster County. Locate this county and briefly describe the land capability and agricultural production from figures 11.33 and 11.35. What do figures 11.36–11.39 indicate about Lancaster County's output of animal products? The patterns in figure 11.40 are very unusual. What sorts of farming practices are being used by the farmers in this area? Why?

In 1969 there were 5560 farms in Lancaster County, twice as many as in any other county in Pennsylvania except for York, where there were 3340 farms. In Pennsylvania, the average size of farms was 58 hectares in 1969, but in Lancaster County the average size was less than 24 hectares. In 1968 farmers in Lancaster County received $123 650 000 in payments—$25 306 000 from crops, $97 812 000 from animals, and the rest from the



1/ Concentrations not delineated are: TOBACCO in Lancaster County, MUSHROOMS in Chester County, and SHEEP in Greene and Washington Counties.

Figure 11.35: Principal agricultural production areas, Pennsylvania (Pennsylvania Crop Reporting Service)

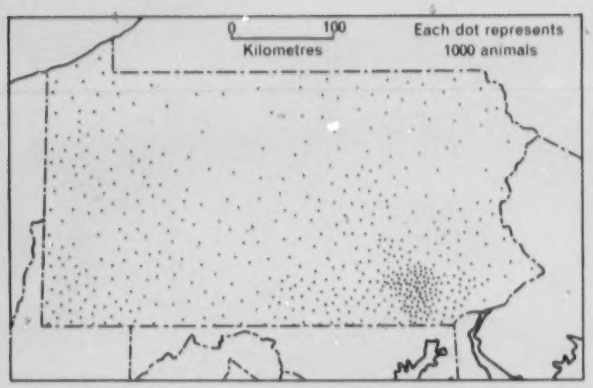


Figure 11.36: Pennsylvania—dairy cows, 1969

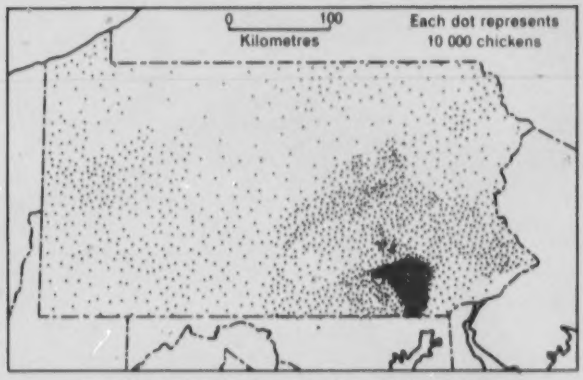


Figure 11.37: Pennsylvania—chickens, 1969

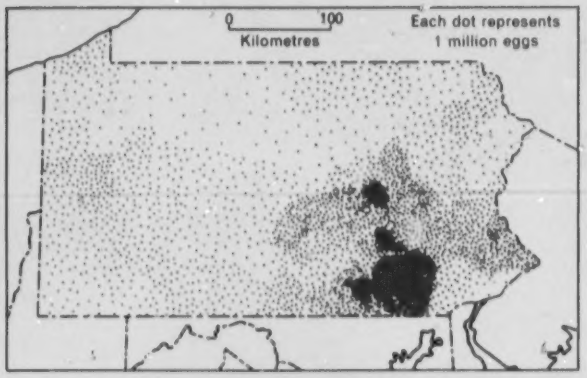


Figure 11.38: Pennsylvania—egg production, 1969

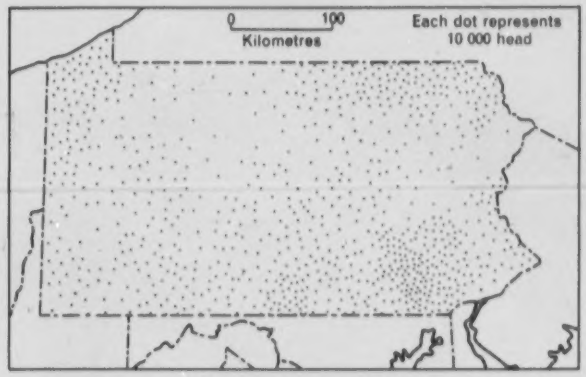


Figure 11.39: Pennsylvania—beef cattle, 1969

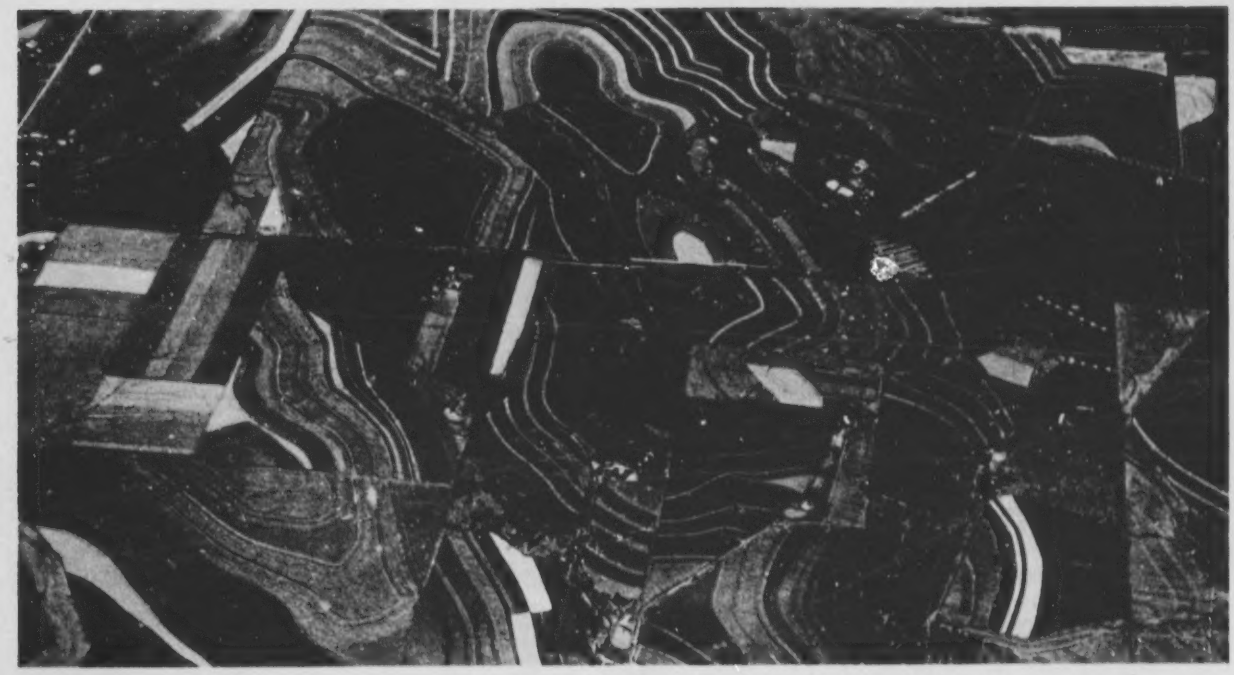


Figure 11.40: Vertical aerial photograph of farmland in Lancaster County (U.S. Department of Agriculture)

government. The next highest-earning county was Chester, with only $57 233 000. Why do you think Lancaster County farmers receive so much more in total than other Pennsylvanian counties? Is it because of the land capability, the types of agricultural production, or some other factor?

Armstrong County is on the western side of Pennsylvania just north-east of Pittsburgh (figures 11.35 and 11.41). In 1968, its total cash receipts for agriculture were $10 835 000, made up of $4 669 000 from crops, $5 825 000 from animal products and $341 000 from the government. Why do its farmers receive, in total, less than those in Lancaster County? In 1968 there were 1130 farms in the county and the average farm size was 47 hectares.

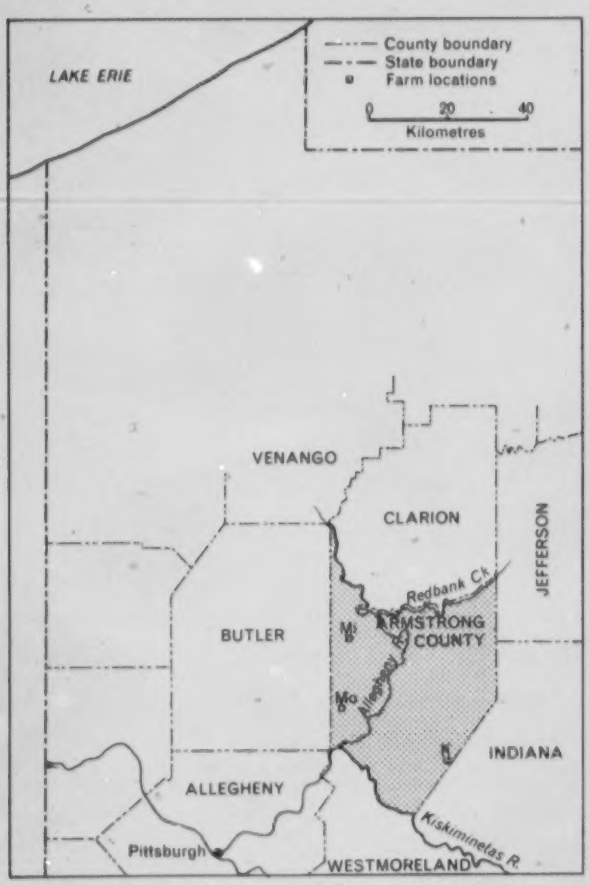


Figure 11.41: Armstrong County, Pennsylvania

Armstrong County is in the Appalachian Plateau area where the rivers have cut down through the rocks, forming what is called a *dissected* landscape. Examine the geologic map, figure 11.42. This dissection has had a marked effect on the shape and capabilities of the land. Table 11.3 shows the degree of slope and the land classes in Armstrong County. How would these factors affect farming in the area?

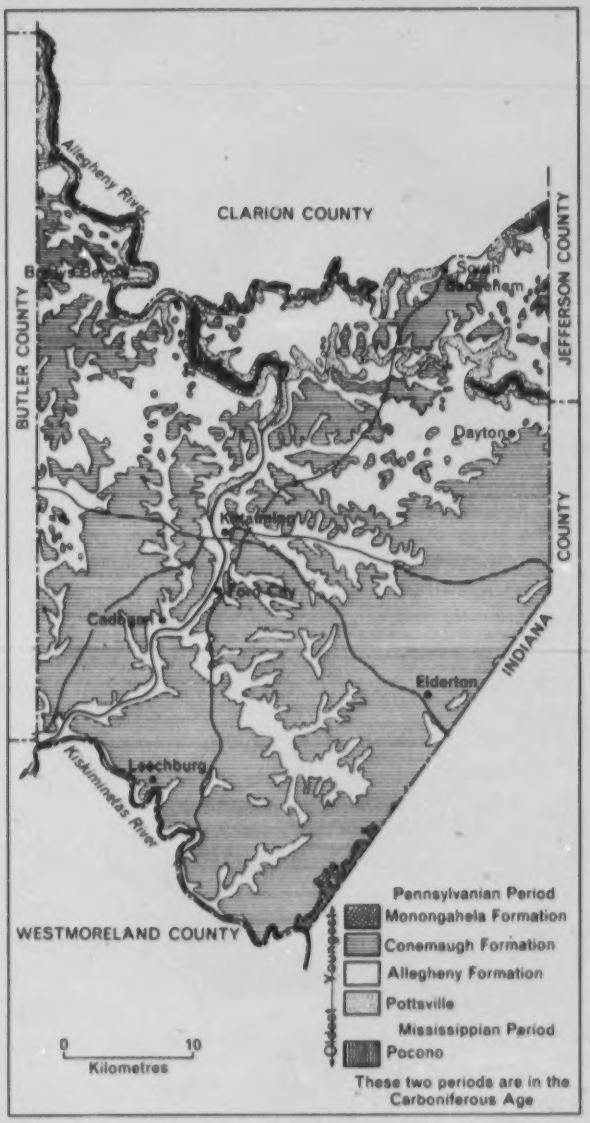


Figure 11.42: Geologic map of Armstrong County (Soil Conservation Service, U.S. Department of Agriculture)

Table 11.3: Land classes* and degree of slope, Armstrong County

Land class		Percentage of total	Slope	Percentage of total
Excellent	I	0·81	0–3%	5·26
	II	18·26	3–8%	22·91
Good	III	24·79	8–15%	20·80
Fair	IV	18·43	15–25%	17·09
Poor	V	4·07	25% +	32·32
	VI	25·92	Water	1·62
Mine spoil		5·33		
Miscell.—gravel and sandpits, limestone quarries, towns		2·39		100·00
		100·00		

*Soils rated on basis of suitability for agriculture

Figure 11.43 shows land use in Armstrong County. What effect does the geology of the county appear to have had on land use? Figure 11.44 shows soils in the county. On what types of soils is farming found?

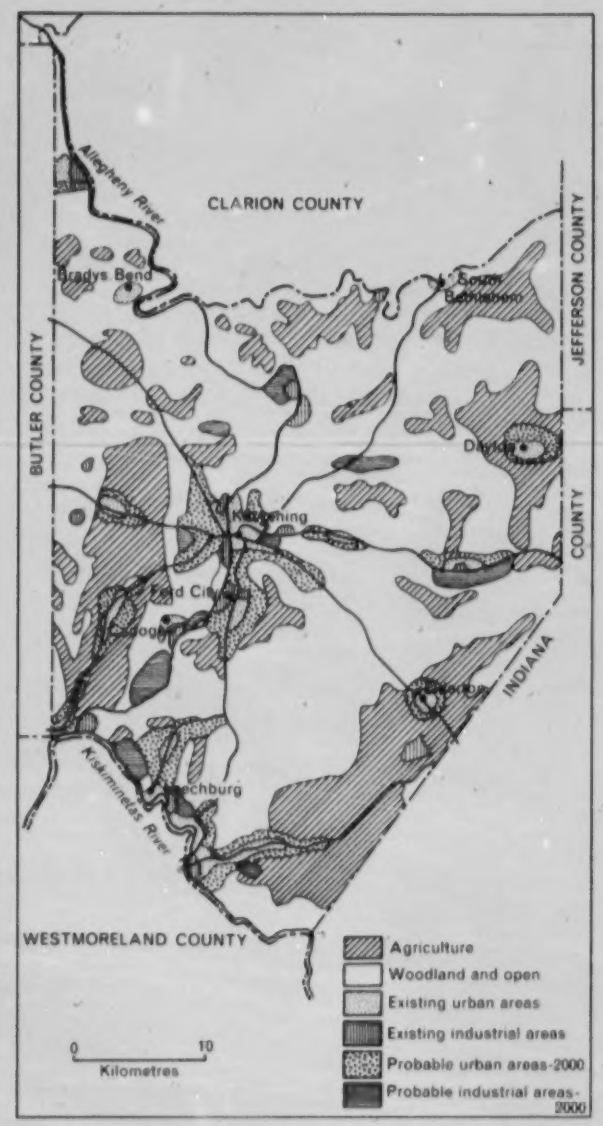


Figure 11.43: Land use map of Armstrong County (Soil Conservation Service, U.S. Department of Agriculture)

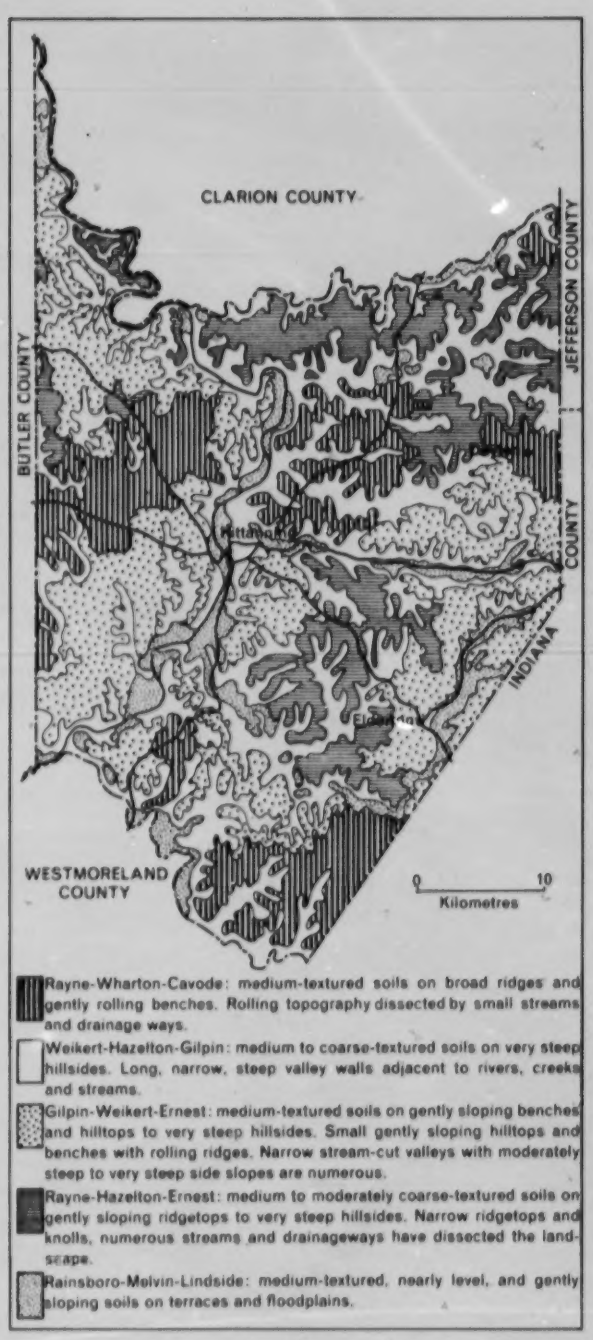

CLARION COUNTY
BUTLER COUNTY
JEFFERSON COUNTY
Kittanning
INDIANA COUNTY
Ebensburg
WESTMORELAND COUNTY
0
10
Kilometres
Rayne-Wharton-Cavode: medium-textured soils on broad ridges and gently rolling benches. Rolling topography dissected by small streams and drainage ways.
Weikert-Hazelton-Gilpin: medium to coarse-textured soils on very steep hillsides. Long, narrow, steep valley walls adjacent to rivers, creeks and streams.
Gilpin-Weikert-Ernest: medium-textured soils on gently sloping benches and hilltops to very steep hillsides. Small gently sloping hilltops and benches with rolling ridges. Narrow stream-cut valleys with moderately steep to very steep side slopes are numerous.
Rayne-Hazelton-Ernest: medium to moderately coarse-textured soils on gently sloping ridgetops to very steep hillsides. Narrow ridgetops and knolls, numerous streams and drainageways have dissected the landscape.
Rainsboro-Melvin-Lindside: medium-textured, nearly level, and gently sloping soils on terraces and floodplains.

Figure 11.44: Soil association map of Armstrong County (Soil Conservation Service, U.S. Department of Agriculture)

Let us now examine three farms to see in greater detail some of the practices and problems of farming in Armstrong County and in Pennsylvania generally.

Figure 11.41 indicates the various farm locations thus: K—Mr Kimmel; Mi—Mr Miller; Mo—Mr Morrison.

The Morrison farm

Mr Morrison's farm is 56 kilometres north-east of Pittsburgh, not far from Highway 28 which runs direct to Pittsburgh beside the Allegheny River. It is a poultry farm, producing eggs and roasting chickens. Mr Morrison has 1500 to 2000 laying hens and 1000 roasting chickens. Each year he

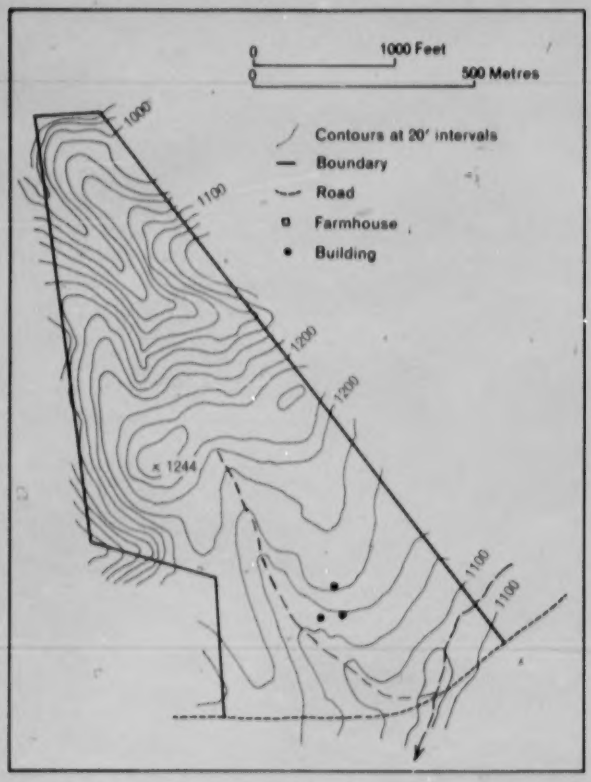


Figure 11.45: The Morrison farm (contour intervals in feet)

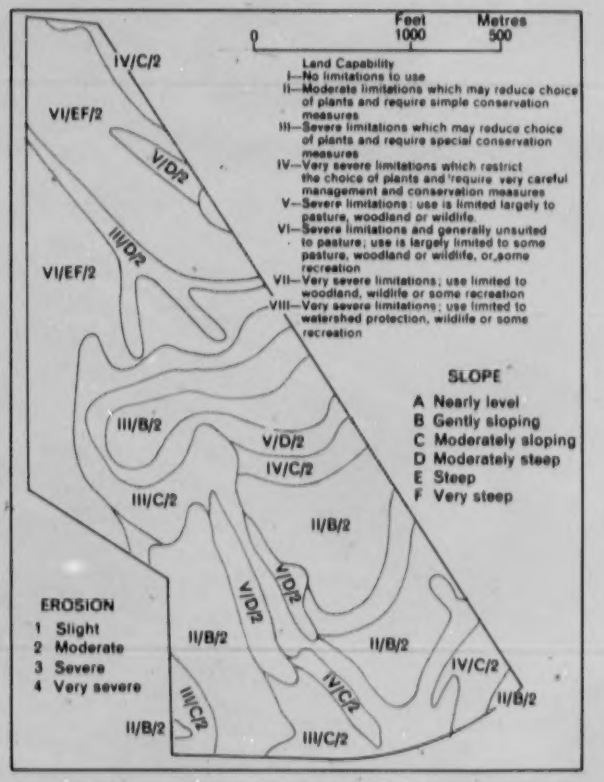
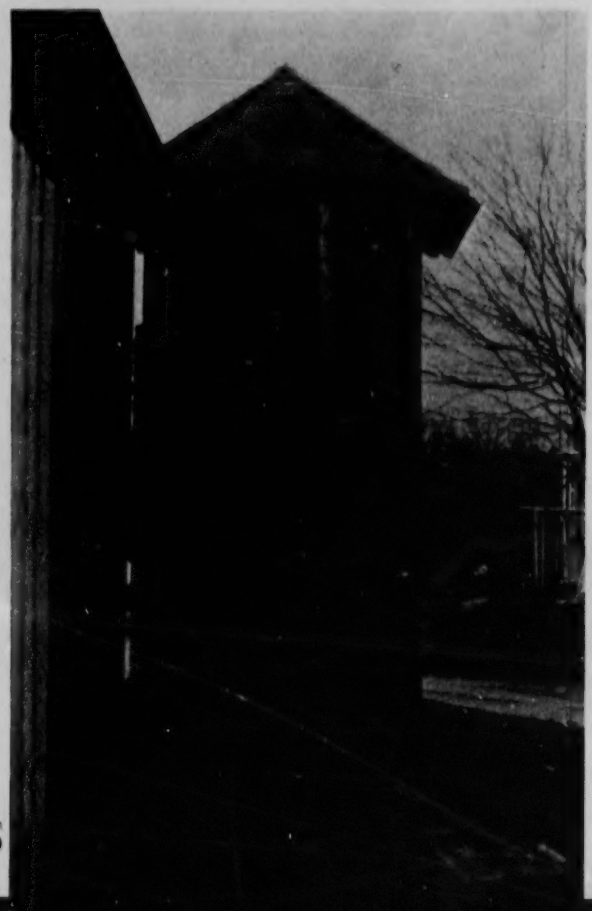


Figure 11.46: Land capability, slope and erosion on the Morrison farm

Figure 11.47: Mr Morrison harvesting corn

Figure 11.48: A home-made corn crib on the Morrison farm



LEGEND FOR CONSERVATION PLAN MAP

Public highway—dirt	Fence row to be removed
Private road	Connected areas
House	Intermittent stream
Property boundary	Diversion
Crop boundary (no fence)	Tile drain
Fence to be built	Grassed waterway or outlet
	Farm pond

Figure 11.49: Conservation plan of the Morrison farm, prepared by the Soil Conservation Service of the U.S. Department of Agriculture

Figure 11.50: Temporary corn cribs and elevator. What is the piece of equipment on the left? (see figure 11.47)

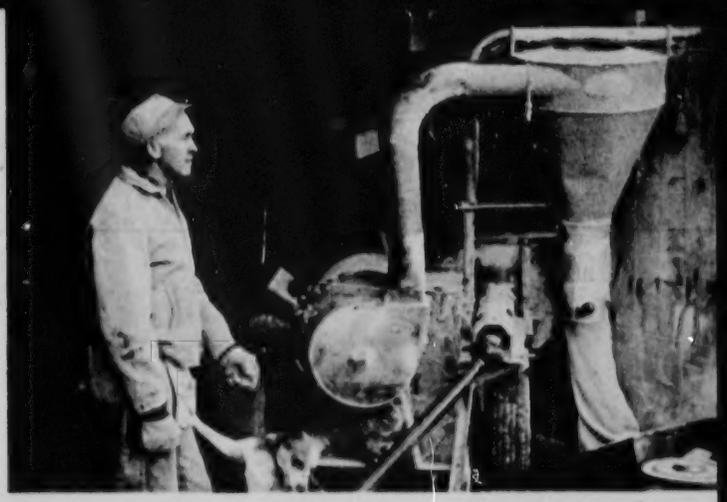


Figure 11.51: Mr Morrison grinding poultry feed

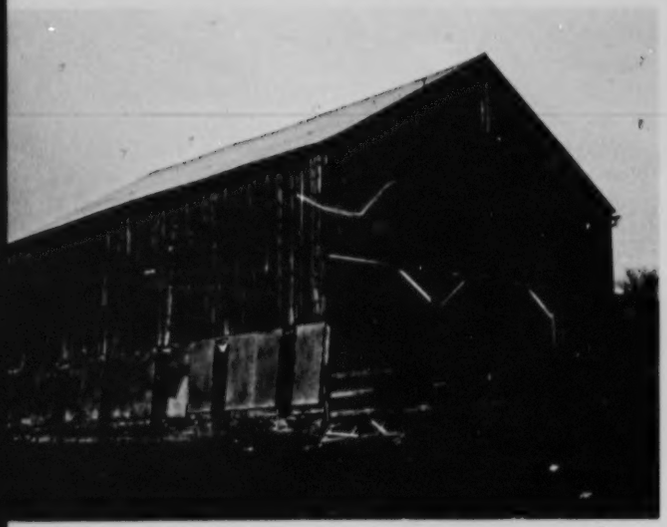


Figure 11.52: The barn

Figure 11.53: Insulated shed for chicks

Figure 11.54: Grazing land on the Morrison farm

Figure 11.55: Looking north across the road to the barn, house and corn cribs, with strip cropping at right

produces 1000 pullet replacements. He also has twenty beef cows and one bull (the calves are sold at eight to nine months as feeders).

The farm is 52 hectares in area, with an additional 50 hectares rented. The land was purchased by the Morrison family in 1811; six generations have lived on the same farm, handing it down for 160 years. Figure 11.45 is a map of the home farm; figure 11.46 shows the results of a survey of the farmland's capabilities. From figures 11.45 and 11.46, can you judge what problems Mr Morrison has on his farm?

To help Mr Morrison cope with these problems, the Soil Conservation Service of the United States Department of Agriculture (U.S.D.A.) has planned that he should use his farm as in figure 11.49. Examine the plan carefully and compare it to figure 11.46. What remedies are suggested for the farmer's difficulties? How could putting in wooded and wildlife areas improve a farm?

On his cropped area Mr Morrison plants corn, oats, barley and hay, normally in a five-year rotation with two years of corn. In cropping sloping land, he strip-crops the area by alternating strips of cultivated crops and grasses. This prevents erosion of the shale, sand and loam soils, which require the use of much manure, chemical fertiliser and lime. (See study 24, pp. 233–34.)

In a number of ways Mr Morrison tries to make his farm independent of outside assistance. For example, he owns two tractors, three ploughs, a cultivator, a disc, a sprayer, a grain drill, a corn planter, a baler, a rake, a mower, a combine, two grain wagons, a grain and hay elevator, a corn picker (figure 11.47), a flat-bed truck, a manure spreader, a manure loader, a corn sheller, a grain auger, a hammer-mill and a rotary mower. By owning all necessary equipment he does not need to bring in contract workers from outside.

Mr Morrison builds his own corn cribs (figures 11.48 and 11.50). When harvesting is complete he mixes the various grains with protein and grinds the mix to make poultry feed (figure 11.51). The poultry are housed in the lower part of the barn (figure 11.52) and hay, straw and grain are kept in the top level, where the feed is mixed and ground. He also keeps a 12 by 24 metre insulated shed (figure 11.53) for the chicks. There are two broods per year.

Mr Morrison also markets his poultry production himself, thus trying to control the entire production process. Apart from the farming operation, he dresses his own poultry for sale and markets the eggs retail from door to door. What are the advantages of doing this? He delivers eggs and poultry once a week 'so as to maintain as fresh a quality product as possible', and maintains the same price all year round. Why?

Beef cattle are grazed to provide supplementary income (figure 11.54) and calves are sold as feeders; Mr Morrison doesn't feed his cattle from the crops that he grows.

When he was asked about the problems of farming, Mr Morrison wrote: 'One of our chief concerns is the use of our agricultural land for other purposes: highways, airports, urban housing, parks, and man-made lakes all are using up our irreplaceable land at a frightening rate when the population is supposed to double in the next thirty years and must be fed from less and less land.'

The Miller farm

Mr Miller was a farmer in West Virginia before moving to Pennsylvania in 1966. In West Virginia his farm was largely taken over to make way for a four-lane highway; he was offered $11 000 compensation, but took the case to court and was successful in having this amount increased to $18 000. However, he thinks that this was still not enough; the case was heard in a city before a town judge and town jury, and Mr Miller feels that city dwellers are unable to understand farmers.

Mr Miller's farm, 163 hectares in area, is located in the north-west of Armstrong County (see figures 11.41 and 11.56). From an examination of figure 11.56, which areas of the farm would Mr Miller find most difficult to use? Why?

Mr Miller is aware of the probability that other types of land use will encroach on his farm. One of the most valuable minerals in Pennsylvania is coal, especially bituminous and anthracite coal (see figure 11.57). In Armstrong County the coal is found in the lower layers of the Allegheny Formation (figure 11.42), which underlie Mr Miller's farm. Much of the coal is obtained by strip-mining the horizontal layers, leaving a desolated landscape and polluted streams. What other problems might

Table 11.4: Seasonal activities on the Morrison farm

	March	June	September	December
Crops	Ploughing Planting		Harvesting (barley, oats, hay) Harvesting (corn) Spray corn for weeds	Seeding winter grain
Poultry	Starting chicks			Starting chicks
Miscell.	Spreading fertiliser			Cutting timber General repairs

result? Since he bought the farm in 1963, Mr Miller has watched strip mining come closer, as miners move north from Kittanning, 15 kilometres to the south (see figure 11.58). He expects to allow them to use one heavily wooded area, which after replanting should be ready for cow pasture in about twenty years. (Miners are now required to replant areas that they have mined.)

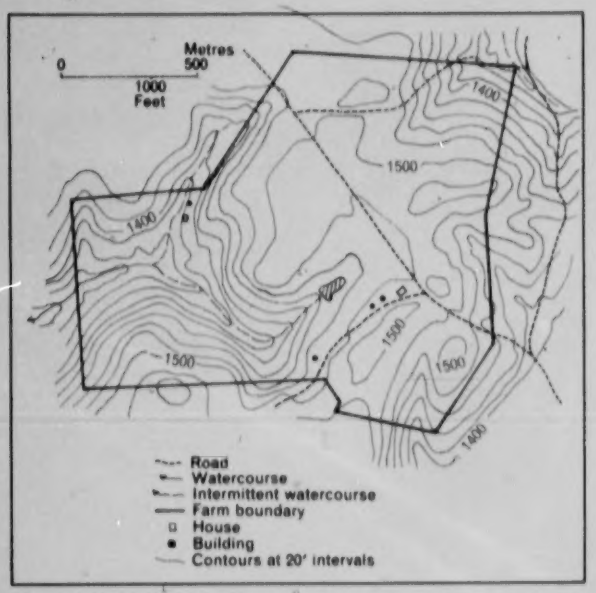


Figure 11.56: The Miller farm (contour intervals in feet)

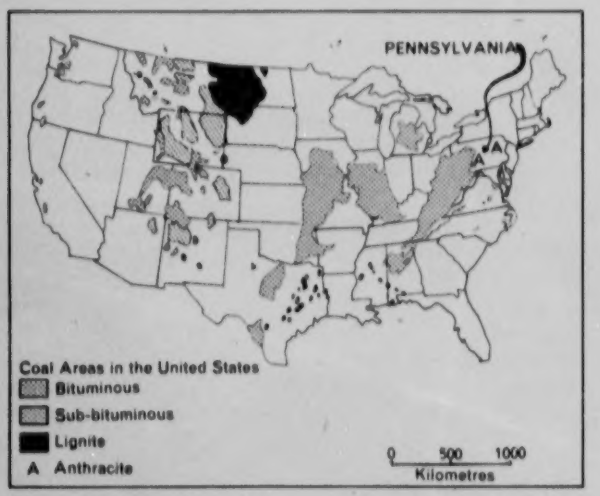


Figure 11.57: Main coal deposits of the United States

In the previous paragraph there is a clue to the main type of production on this farm. Basically Mr Miller produces milk, and occasionally he sells some cattle when necessary. Daily production of milk is about 900 kilograms, which in 1970 was returning him, on average, about $120 daily. Milk is divided into Classes 1 and 2. Class 1 is high-

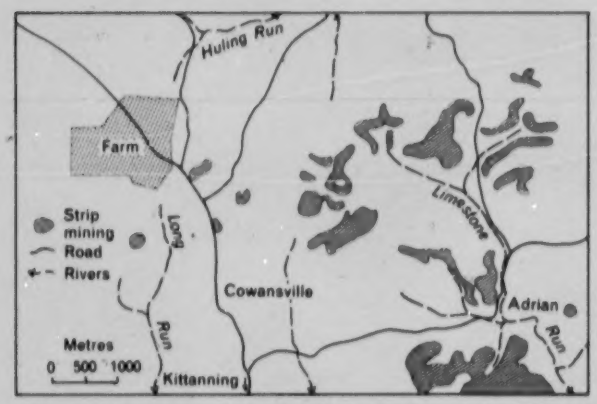


Figure 11.58: Strip mining south-east of the Miller farm in 1963

class, suitable for consumption as fresh milk, while Class 2 may be used in cheese and butter production, for example. When milk goes to the dairy the Class 1 quota is filled and the remainder goes to Class 2. The butterfat content is measured for every load and this affects the price paid for the milk. Mr Miller's milk is collected every second day and he generally receives the highest ruling price for it.

There has been a long history of dairy farming in Mr Miller's family, which may help explain his concentration on this type of production. The farm, however, has 81 hectares in woodland and only 20 hectares under pasture. The remainder comprises 16 hectares of corn, 8 hectares of small grains, and 38 hectares of hay meadows (alfalfa, clover, timothy). Examine figure 11.59 and try to work out which parts of the farm are devoted to the different types of land use. Does land use as shown in the photograph match your earlier ideas about the difficult areas on Mr Miller's farm? How do the different types of land use relate to the farm relief (figure 11.56)? When the U.S.D.A. Soil Conservation Service surveyed the farm in 1968, they produced the map in figure 11.60 and recommended the changes in figure 11.61. Why do you think they suggested these changes? Do you agree?

One of the reasons for requesting the Soil Conservation Service survey was the effect of heavy rains during planting in April and May. There are several steep slopes under crop and these suffer soil run-off during heavy rain. The soil is an easily worked silt loam on which Mr Miller uses a commercial fertiliser (nitrates, potash, phosphate) to balance the large amounts of animal manure.

The animal manure is obtained from Mr Miller's herd of 95 registered Holstein dairy cattle (figure 11.62) during the winter period. While snow covers the ground the cattle are kept in the dairy barn, which has a hay storage for ease of feeding (figure 11.63). The milkhouse adjoins the barn.

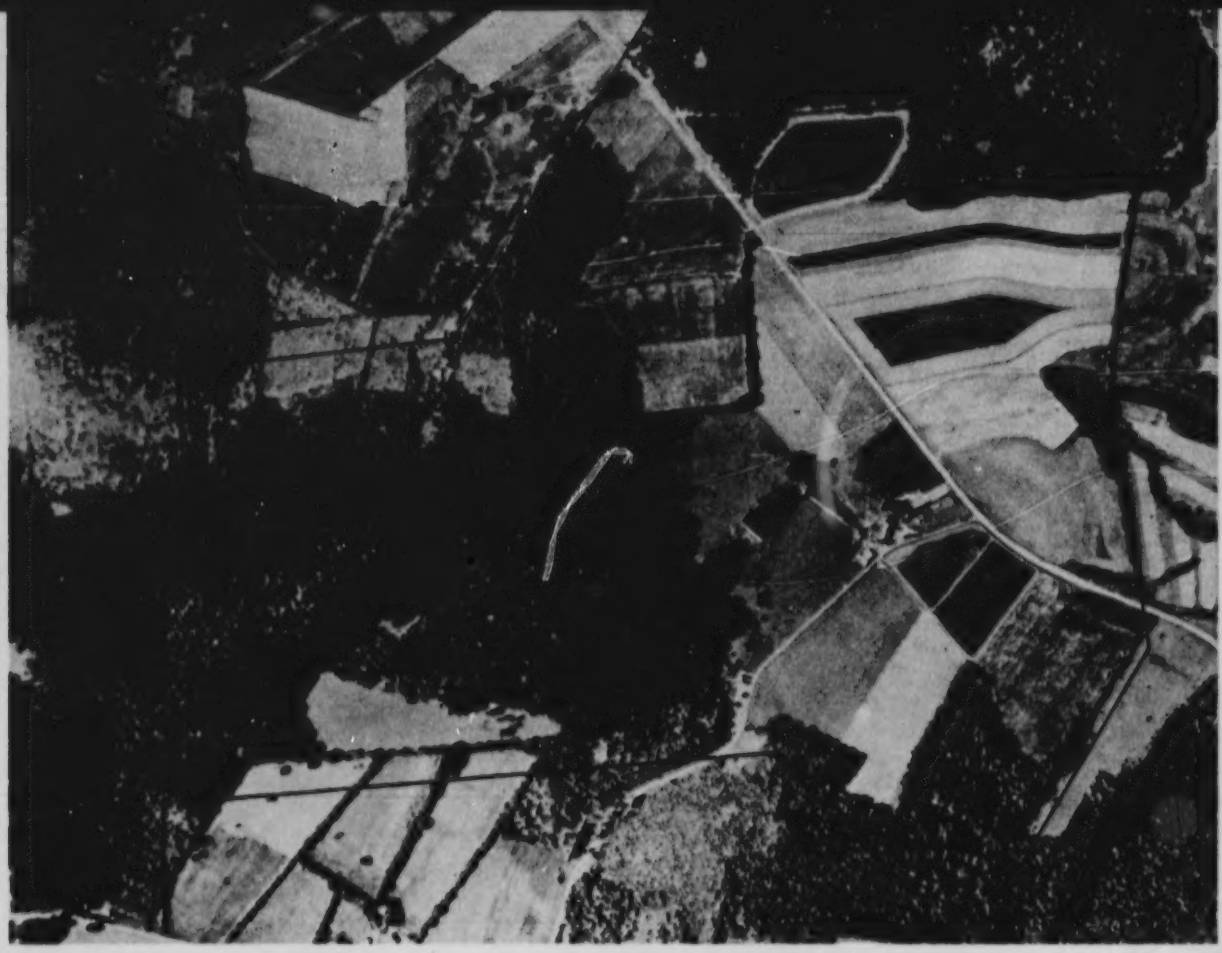


Figure 11.59: Vertical aerial photograph of the Miller farm in 1968

SLOPE
A Nearly level
B Gently sloping
C Moderately sloping
D Moderately steep
E Steep
F Very steep
II/B/2
III/A/2
III/C/2
III/B/2
IV/B/2
V/CD/1
IV/D/2
Land Capability
I—No limitations to use
II—Moderate limitations which may reduce choice of plants and require simple conservation measures
III—Severe limitations which may reduce choice of plants and require special conservation measures
IV—Very severe limitations which restrict the choice of plants and require very careful management and conservation measures
V—Severe limitations: use is limited largely to pasture, woodland or wildlife
VI—Severe limitations and generally unsuited to pasture; use is largely limited to some pasture, woodland or wildlife, or some recreation
VII—Very severe limitations; use limited to woodland, wildlife or some recreation
VIII—Very severe limitations; use limited to watershed protection, wildlife or some recreation
EROSION
1 Slight
2 Moderate
3 Severe
4 Very severe
0 metres 500
0 feet 1000

Figure 11.60: Land capability, slope and erosion on the Miller farm

Because of the winter conditions, most farming activities occur from spring to autumn. The crops are planted in April–May and harvested from June to August. The silo (figure 11.63) is filled in September, and corn is picked in October and stored in corn cribs in preparation for the winter. Besides the daily milking there is a considerable amount of general activity, especially in putting the Soil Conservation Service plan into operation: tracing and concreting springs to bring about efficient distribution of water; draining level land; slightly altering contour ploughing lines; clearing woodland to enlarge the pasture area (figure 11.64); and planning long-term developments in new pasture.

At the centre of the farm operation are the farm buildings (figures 11.63, 11.65 and 11.66). In these photographs, identify the silo, the main dairy barn and hay storage, the calf barn with overhead hay storage (smaller than the main dairy barn), corn cribs, main residence and equipment sheds.

Mr Miller's farm is a highly efficient operation based on a single type of production. His careful planning appears to have considered all possible future developments that could affect or disrupt his production.

LEGEND FOR CONSERVATION PLAN MAP

═══	Public highway—hard surface	—x—x—	Fence, present permanent
═══	Public highway—dirt	—I—I—	Fence to be built
■	House	—o—o—	Fence row to be removed
———	Property boundary	—T—T—T—	Tile drain
- - - - -	Crop boundary (no fence)	◎	Farm pond

Figure 11.61: Conservation plan of the Miller farm, prepared by the Soil Conservation Service of the U.S. Department of Agriculture

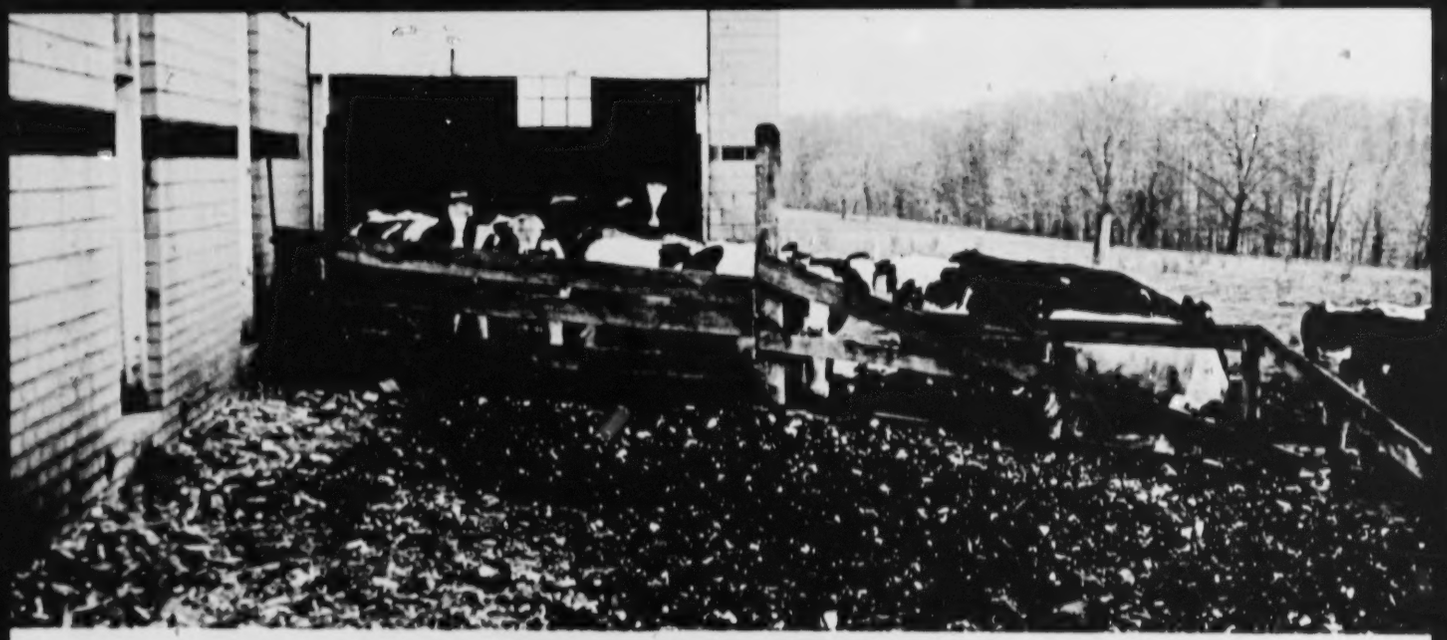


Figure 11.62: Holstein dairy cattle on the Miller farm

Figure 11.63: The barn, hay storage, milkhouse and silo on the Miller farm

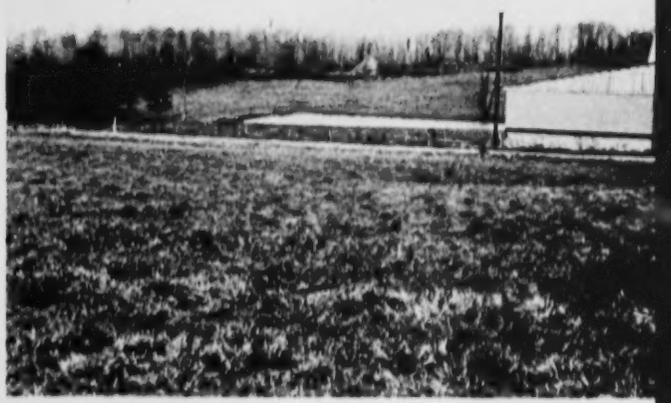


Figure 11.64: Looking west across the dam to cleared woodland; note the large pile of sawdust

Figure 11.65 - Looking south from the highway to the farm buildings

Figure 11.66: The Miller farmhouse

The Kimmel farm

Mr Willard Kimmel's farm operation is located in the south-east of Armstrong County (figure 11.41), and consists of one home farm and nine smaller separate plots.

The original or home farm was purchased in 1910 by Howard Kimmel. As his son Willard grew up and joined the farm operation, they bought more land, increasing the area to about 140 hectares. Over the years Willard added more land, both bought and leased. His son Chris joined the operation in the 1960s, and now the area they farm has grown to 400 hectares. Their main farming activity is the production of grain crops, as listed in table 11.5.

Table 11.5: Mr Kimmel's land use

Crop	Area (hectares)
Corn	142
Wheat	40
Barley	40
Oats	28
Rye	16
Hay	20
Pasture	61

Corn is the main grain crop; from it, 1500 tonnes of silage is made for feeding beef cattle, the remainder (75 tonnes) being shelled in the field, dried and stored or sold. Some land is permanently under corn, whereas other land is rotated, corn being planted as often as soil conditions will allow. Also, some land is left fallow for a year.

Three-quarters of the grain corn is sold to local poultry-men and feed mills, as is all of the wheat. The barley, oats and the rest of the corn are fed to the 400 beef cattle that the Willards fatten and sell to nearby slaughterhouses, which retail the meat locally. The sale of beef cattle provides the main component of farm income.

Thus most of the farm plots have the typical barn and silo where the cattle are conditioned and fed, especially in winter (figures 11.67–11.69). Figure 11.67 shows the home barn for 250 head of cattle. There is a grain store with a capacity of 1000 cubic metres and space for 30 000 bales of hay and straw, and machinery sheds for the farm equipment, which is worth about $50 000.

The home farm is contained in a bend of Crooked Creek, with one of the farm plots less than two kilometres away (see figure 11.70). Three groups of buildings are visible on the map of the home farm area. The one to the west of the road running through the farm is Willard Kimmel's (figure 11.71), and Chris Kimmel's is the more northerly of the two groups to the east of the road (figure 11.72).

Figure 11.67: Willard Kimmel's barn and silo for cattle and fodder

Figure 11.68: In the middle distance, Chris Kimmel's silos and animal shelter. What form of development appears to have taken place in the far distance?

Figure 11.69: Willard Kimmel's calf barn

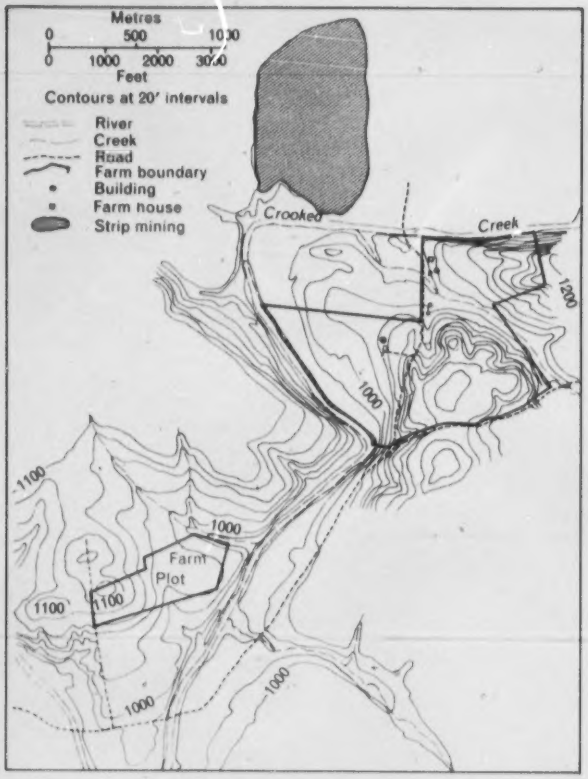


Figure 11.70: The Kimmel home farm and one farm plot (contour intervals in feet)

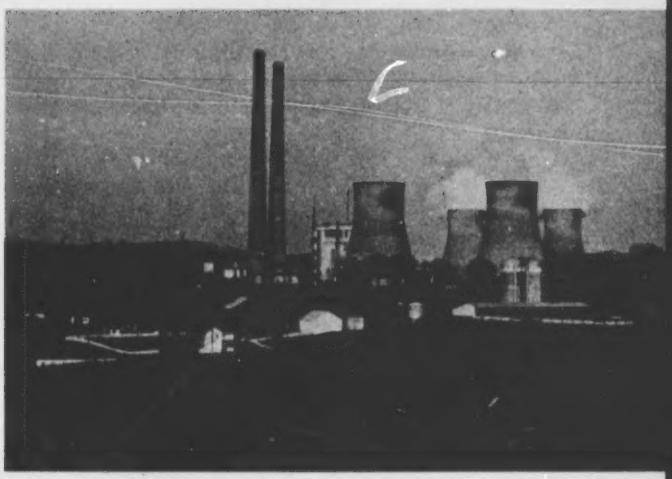


Figure 11.72: Chris Kimmel's house and barns

Figure 11.71: Willard Kimmel's homestead and barns

Figure 11.73: Keystone Power Station and coal stockpile. What means of transport is being used here?

Figure 11.74. Vertical aerial photograph of the home farm

As you can see in figure 11.72, to the north of Chris Kimmel's there is a new power station based on local coal (note the strip mining on the northern side of Crooked Creek in figure 11.70). The Keystone Power Station is a major component of a $750 000 000 interrelated power development undertaken by investor-owned utilities in the four states of Pennsylvania, New Jersey, Delaware and Maryland. The station consumes 350 tonnes of coal per hour, delivered by conveyor belt or by truck (figure 11.73).

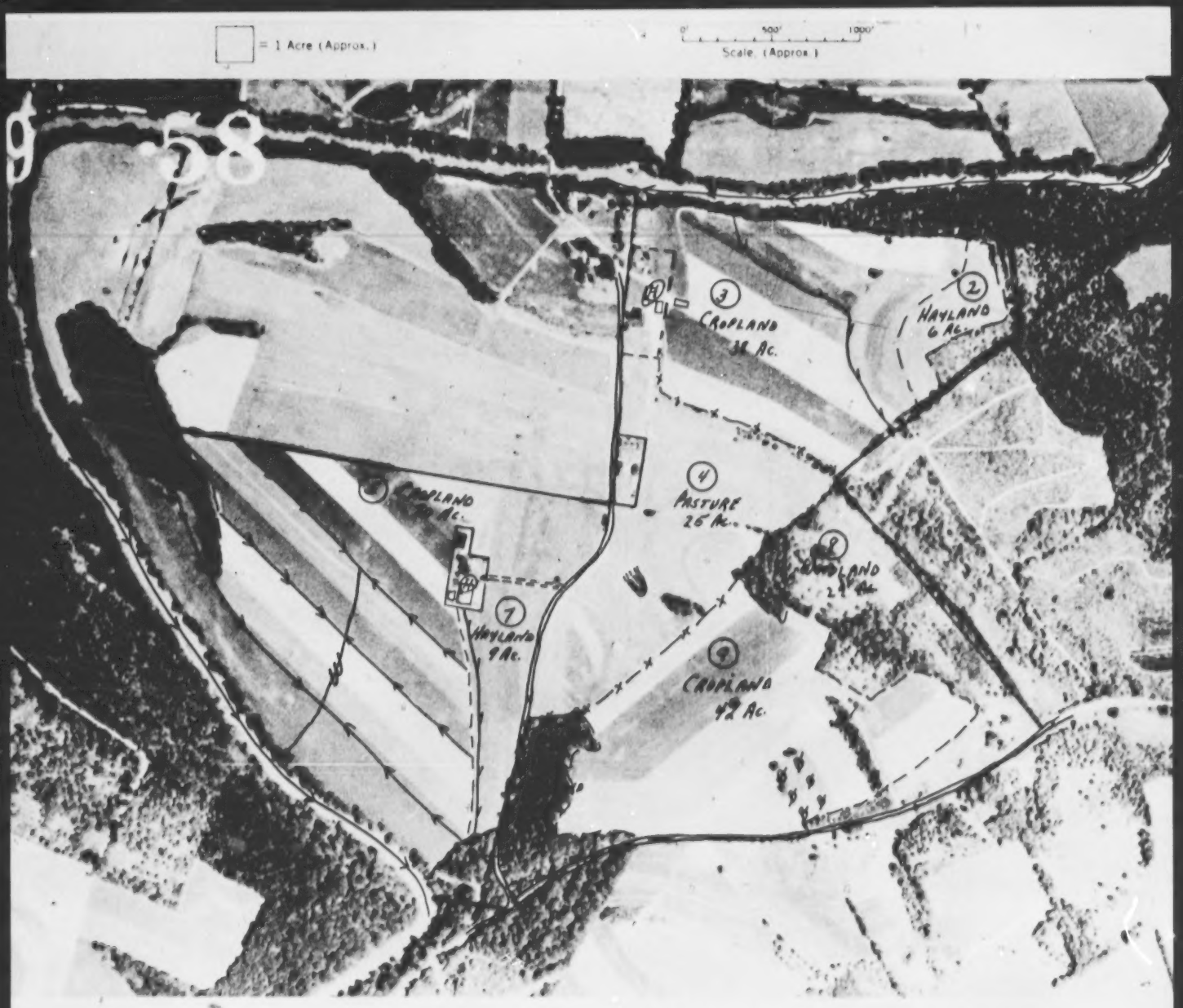
By examining figure 11.70, you should now be able to make some assessment of the land capability of the home farm (figure 11.74). Does your assessment agree with the Soil Conservation Service's survey (figure 11.76) and their plan (figure 11.75)?

The S.C.S. recommended erosion control measures for some parts of the farm. Whereabouts on the farm are these measures recommended, and why do you think they were suggested? What other changes did the S.C.S. suggest?

The Kimmels have been practising soil management techniques for some time. Examine figure 11.77. What has been done in this area, and why? Special care needs to be taken on land continually cropped by corn, as corn depletes the soil and destroys its stability (see pp. 227, 232).

Winter is cold in this area—the winter temperature averages –1 C and sometimes reaches –12 C—and during this time machinery is repaired, land cleared, field drainage replaced, manure hauled and general maintenance carried out, apart from the major job of feeding the cattle.

From March to November the ploughing, planting and harvesting of crops is the most time-consuming activity.



LEGEND FOR CONSERVATION PLAN MAP

Public highway—dirt	Connected areas
Private road	Stream
House	Terrace
Building	Diversion
Property boundary	Grassed waterway or outlet
Crop boundary (no fence)	Cut-back border or field border planting
Fence, present permanent	Farm pond

Figure 11.75: Conservation plan of the Kimmel home farm, prepared by the Soil Conservation Service of the U.S. Department of Agriculture

Figure 11.76: Land capability, slope and erosion on the home farm

The Kimmels have not commented on the effect of the power station; so far it appears to have had little impact on the local environment. They are more concerned about the effects that labour unions may have on farming. One of the Kimmels' reasons for preferring beef cattle in a generally dairying area is that the labour requirements are less than for dairying, and can be kept within the capability of the family operation.

The Morrison, Miller and Kimmel farms have concentrated on animal products of a differing nature.

What reasons could you find in the descriptions to explain the farmers' choices of particular types of activity?

Draw diagrams of the three farms to show how their inputs and their outputs differed. What problems did each farmer face? Were they similar?

Do you think farming is the best way man can use these three areas of land? Do the farmers experience so many difficulties that it would be preferable to turn over the land to woodland and recreational activities?

The Armstrong County Soil and Water Conservation District Program reported on the problems of agriculture in the county in this way:

The farm population in Armstrong County decreased from 11,960 in 1950 to 4,318 in 1964. The number of farms and acreage in farms decreased from 1954 to 1964 while the size of farms increased. . . . Statistics reflecting these changes are shown in Table [1].

Figure 11.77: Ploughed area—green: rye grass; brown: corn

TABLE [1]
Change in farms—Armstrong County

Number of Farms		Farm Decrease	Acreage in Farms*		Acreage Decrease	Size of Farms		Average Size Increase
1954	1964	Percent	1954	1964	Percent	1954	1964	Percent
2,026	1,248	38·4	205,577	164,470	19·9	101·5	131·8	29·8

*Includes cropland, pasture, woodland, and other land in farms

Most of the acreage decrease in farms occurred in cropland, and other land in farms. The land going out of agriculture went primarily to urban, woodland, recreation, and other non-farm uses. . . .

In 1967, Armstrong County's 1,130 farms received cash receipts amounting to $6,908,000 from the sale of their products. Of this amount, $3,343,000 was derived from dairy products, $1,391,000 from livestock products, $1,026,000 from poultry products, $809,000 from field crops, $78,000 from fruit and nuts, and $161,000 from vegetables. The total county agricultural income including forest and horticultural products amounts to about 4·5 percent of the manufacturing income which totalled $154,715,000 in 1967.

Many of the farmers are reluctant to borrow money for working capital or expansion of their farm enterprises because of uncertain future agricultural income. Off-farm work by the operator or members of his family provides a major source of income to many farmers. Statistics for such employment in 1954 and 1964 are shown in Table [2].

TABLE [2]
Off-farm employment

	1954	Percent	1964	Percent
Total number of farms	2,026		1,248	
Operators working off the farm	1,021	50·4	689	55·1
Operators working off the farm 100 days or more	766	38·3	561	44·9

. . . An important new farm management tool is the cost and return data developed by the Soil Conservation Service. This information provides a sound economic basis for those planning or managing agricultural, woodland, or recreation enterprises. Deep, well-drained soils will provide an average net profit of about $60 per acre for a crop of corn for grain; if this same crop is grown with the same management, same moisture, in the same growing season, but on a shallow well-drained soil, there would be an average net loss of about $20 per acre. The ratio between these two profit figures is about the same each year although the actual figures may increase or decrease in a given season.

Monongahela and Wharton are examples of deep, moderately well-drained soils of the county. They are among the best agricultural soils. They usually produce the highest yields and have the greatest net profit.

Representative of a shallow well-drained soil is Weikert. This group of soils will usually produce a greater return if used for hay and pasture. . . .

The acreage in cropland is decreasing, as previously indicated. Table [3] shows the extent of the erosion, water, and unfavorable soil condition problems associated with this land.

TABLE [3].
Estimate of needs for conservation treatment on cropland, 1968

Type of problem	*Acres*
ACREAGE OF CROPLAND	
Total	101,525
Treated	22,996
Needing Treatment	78,529
LAND WITH NO LIMITING PROBLEM	
Total	41
Treated	41
Needing Treatment	0
DOMINANT EROSION	
Total	93,193
Treated	21,166
Needing Treatment	72,027
DOMINANT EXCESS WATER	
Total	8,110
Treated	1,830
Needing Treatment	6,280
DOMINANT UNFAVORABLE SOIL CONDITIONS	
Total	181
Treated	0
Needing Treatment	181

Erosion is a dominant problem on most of the sloping, well-drained land. It is also a secondary problem on much of the sloping land having excess water or unfavorable soil conditions. Strip cropping and contour cultivation are effective in controlling erosion on slopes up to 250 feet in length. The use of minimum tillage with these practices improves their effectiveness. Grassed waterways should be left or established in draws and depressions. Diversions with strip cropping provide excellent protection on slopes more than 250 feet in length. Gradient terraces may also be used on slopes up to 10 percent. Safe outlets must be established before diversions and terraces are installed.

Where excess water is a problem on sloping land, additional practices should be used to provide adequate drainage. Strip cropping and contour cultivation should be laid out on grade and frequent waterways provided to

improve surface drainage. Open drains and diversions can be used to remove excess surface water. Random and interceptor tile lines can be used to improve surface and internal drainage. [See study 24, p. 231.]

The effectiveness of these practices in controlling erosion is determined, to a large extent, by the crop rotation used with them. Rotations which include a high percent of sod-farming or close-growing crops which protect the land surface throughout the year are considered best for preventing erosion and maintaining fertility and tilth. Where drainage is a problem, the rotations should include crops that will tolerate wet soil conditions. Hay or crops that mature or can be harvested by early or mid-summer are best suited on land having unfavorable soil conditions.

The more the land is plowed and cultivated, the greater the erosion hazard. The less intensive rotations should be used on the steeper and more severely eroded land. The more intensive rotations should be used on gently sloping, less eroded land. Winter cover crops should be used where a row crop follows a row crop in the rotation. Crop residue should be managed so that it will provide the maximum protection to the soil surface.

Where excess surface water alone is a problem on level to gently sloping land, open drains, diversion and bedding systems can be used to remove the excess surface water. Land grading can be used to reshape the land surface to expedite the flow of excess surface water into the drainage outlets. Frequent waterways should be provided to serve as outlets for the drainage from the graded rows. Tile can be used to correct seepy conditions and poor internal drainage on most of the soils. The effectiveness of tile is determined largely by the rate at which water moves through the soil profile. Flooding may be prevented by improving stream or drainage channels, or by the installation of dikes and levees.

Land which has an unfavorable soil condition problem is usually shallow, droughty, and low in fertility. This land can be protected and improved in about the same manner as land having a dominant erosion problem. Shallowness to rock may hinder or prevent installation of diversion terraces. Hay or crops that mature or can be harvested by early or mid-summer are best suited for this land.

Soil fertility and tilth are important factors in both crop production and land protection. The crops and land respond to applications of lime, fertilizer, and manure. The land should be limed regularly to meet the needs of the crop to be grown. Liberal amounts of fertilizer should be used to provide adequate plant nutrients for growth and economic yields. Manure is a source of some plant nutrients and organic matter which improves soil structure and tilth. Vigorous plant growth provides more protection for the land surface than less vigorous plants. Soils with a loose, porous structure and good tilth will absorb more water than those with poor structure and tilth.

The acreage in pasture has been increasing . . . . Table [4] shows the type and extent of problems associated with this land.

TABLE [4]
Conservation needs on pastureland, 1968

Treatment and Dominant Problem	*Acres*
Total pasture area	**26,540**
No treatment needed	**6,162**
Treatment needed*	**20,378**
Protection of vegetation from:	
Overgrazing	647
Erosion	6,158
Encroachment of plants	216
Improvement of vegetation	7,000
Establishment or re-establishment of vegetation	12,515
Drainage	3,884

*More than one type of treatment may be needed on the same area

There are 12,515 acres that should be established or re-established through renovation and new seedings. Improvement of vegetation through liming, fertilizing, mowing or other similar practices is needed on 7,000 acres. Protection of vegetation from overgrazing is a problem on 647 acres, from erosion on 6,158 acres, and from encroachment of undesirable plants on 216 acres. Excess water, which prevents the adequate establishment, maintenance, and use of desirable vegetative cover, is a problem on 3,884 acres. This problem can be improved or corrected through the use of tile drainage.

How does farming in Armstrong County differ from that in the St Lawrence Lowlands? Why do you think the differences exist?

As the three farms we have examined depend so much on crops, can they survive in the situation described in this report? Do you think they should be helped to survive, in the light of man's need for food?

You have now read about a number of different ways of producing food. You will have seen how the types of products vary (*outputs*), how the farms vary (centre of the *system*) and how the farmers' methods and activities vary (*inputs*). Which types of farming are most efficient? Which conserve the land most successfully? Why do farms differ, even in very similar areas?

Each farmer or group of farmers faced certain problems. Were they able to overcome them? How? Make a scrapbook of news items and articles about the problems that farmers encounter. Do you agree with the different subsidies that farmers receive from governments? How can the people of this world receive enough food at suitable prices when the costs of farming and of solving agricultural problems are rising all the time? Some farmers barely produce enough to sustain themselves—what changes are necessary to meet their food requirements?

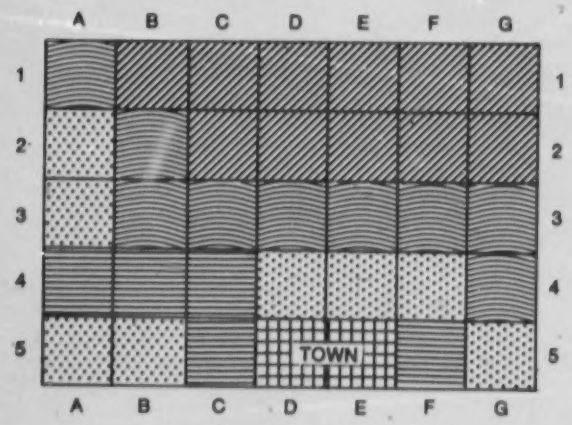
12

What land will you settle?

In this section, you have the chance to be a farmer. Read the context carefully and the details about the land to be settled, and then your teacher will help the class to colonise the area.

CONTEXT

This is a frontier region. You have come here with the intention of becoming a farmer—you want to buy a block of land, clear it and settle on it, using it to obtain your income. Up to this time you have worked as a farmhand on nearly all types of farms, so your experience is very wide. What money you have saved you have invested, and your investments have done very well, so now you find yourself with 50 agrits with which to buy a block and set up your activities. In addition, the government has provided you with a further 10 agrits as a subsidy for opening up new land. (Loans are not available to cover excess expenditure in the first year of operation, but may become obtainable in subsequent years.) It has been your life's ambition to own your own farm and farm it as you please.



Area I: This is a plains area; the soil is deep and sandy, and the climate is warm and dry.

Area II: Steep mountainous country; the soil is shallow and relatively infertile, but this is offset by a very good rainfall.

Area III: Hill country; the soil is good and rainfall is also good, but not as high as in area II.

Area IV: Alluvial flats; extremely fertile soil and a good rainfall similar to that of area III.

Figure 12.1: Blocks for sale

Examine figure 12.1. There are thirty-three blocks for sale in the district, all to be sold by auction. Before you start buying you will have to estimate how much you can afford, taking into account your expenses for the first year of operation—the cost of clearing the block (figure 12.2), living costs (4 agrits for the first year), the cost of setting up and running the farm (table 12.1), and the cost of transporting your produce to market (figure 12.3 and table 12.2). Read the following four paragraphs for more information on these cost factors. The value of a block will depend on how far it is from the town, whether the soil is fertile, whether the rainfall is high or low, and the topography of the land, to name but a few factors. When you have considered all these aspects and decided how much you can allocate to the purchase of a block, an auction will be conducted in the classroom, each would-be farmer bidding for the block of his choice.

Once you have bought a block of land you will have to clear it. The cost of clearing the block depends on the topography and the thickness of the native vegetation. Costs of clearing are shown in figure 12.2 and range between 2 agrits and 10 agrits.

Now that you have cleared your block you can decide what farming activity (or activities) you will carry out. For marketing reasons you only have a choice of wheat, oats, potatoes, peas, dairy cattle, beef cattle and mutton/wool. Of course, the decision you make will be based on the physical characteristics of the area in which you own land and the amount of cash you have left after purchase and clearing. It may also be influenced by forecasts for various farming activities in the first year of operation—you will be provided with a list of news items from magazines, suggesting possible future trends in the markets for different types of primary produce. You should not forget that you must allocate 4 agrits in the first year for living

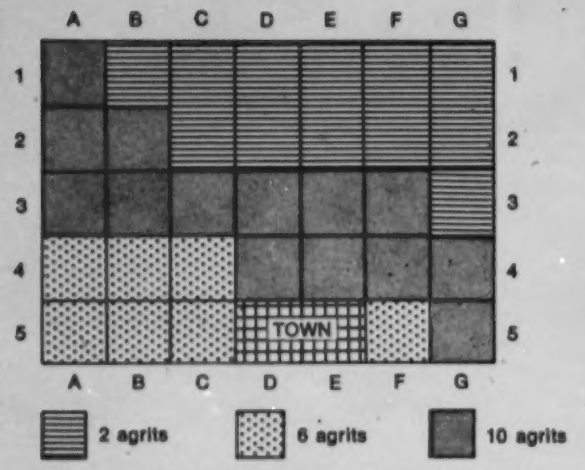


Figure 12.2: Clearing costs

costs. This amount allows for food, clothing, annual holidays, repayments on your house, etc. (it will rise in subsequent years to allow for inflation).

Refer to table 12.1. Running costs for the various farming activities are expressed in agrits per quarter-farm, so that you may diversify your activities if you wish. These costs include seed for pasture or crop, oil and petrol for machinery, maintenance of machinery and outbuildings, depreciation of machinery and outbuildings, fees for specialists such as veterinarians and agricultural consultants, fertiliser and pesticides, and many other items. There are also a number of costs that occur during the first year only, such as putting up sheds, buying equipment and machinery and erecting fences. These 'setting up' costs are whole-farm costs. Thus, if you were setting up a dairy farm, in the first year you would pay 4 x 3 agrits for running costs and 24 agrits for 'setting up' costs, making a total of 36 agrits.

Table 12.1: Setting up and running costs

	Running costs (per quarter-farm)	'Setting up' costs (whole farm)
Dairy cattle	3 agrits	24 agrits
Beef cattle	6 „	12 „
Mutton/wool	6 „	15 „
Wheat	9 „	15 „
Oats	9 „	15 „
Potatoes	18 „	9 „
Peas	15 „	9 „

Another factor affecting your choice of farming activity will be the cost of transporting produce to the market, that is, the town. If you look at figure 12.3 you will see how many units of distance you are from the town. Now refer to table 12.2. The cost of transporting each product is different; therefore

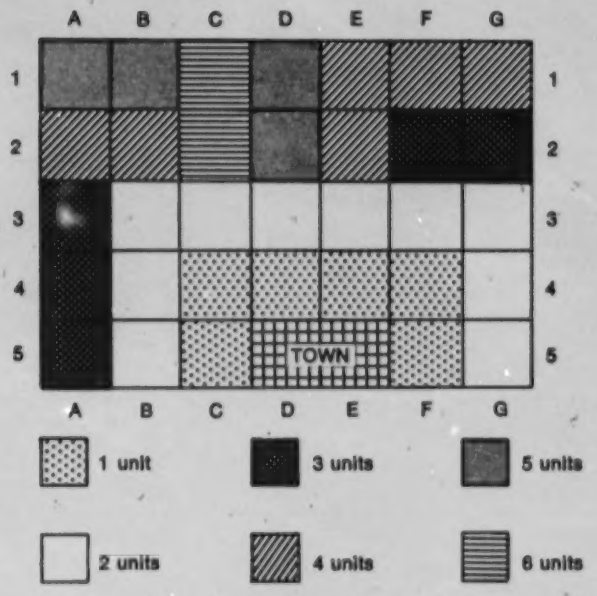


Figure 12.3: Distance from town

Table 12.2: Transport costs (per quarter-farm) of produce per unit distance

Dairy products	1·5 agrits
Beef	1·0 „
Mutton/wool	1·0 „
Wheat	1·0 „
Oats	1·0 „
Potatoes	3·0 „
Peas	2·0 „

it will be uneconomic, say, to transport potatoes from square C1 as cost of transport for each quarter-farm of produce = 6 x 3 = 18 agrits.

A dairy farmer on A3 would have to pay a total of 4 x 1·5 x 3 (4 quarter-farms x 1·5 agrits x 3 units of distance) = 18 agrits.

A farmer on E2 who has half a farm in dairy cattle and the other half in beef will pay (2 x 1·5 x 4) + (2 x 1 x 4) = 12 + 8 = 20 agrits.

However, transport costs—although they must be anticipated in planning the farming activities—are not an initial expenditure. They are incurred in the marketing process, and are deducted from the gross return from produce.

If, during the auction, you paid a very high price for your land, or if other expenditures have been heavy, you may find yourself unable to farm the whole block in this first year, but don't worry, for if you have carefully selected your crops/livestock you may be able to do this the following year! If, on the other hand, you have any excess cash, it will be regarded as being deposited in the bank and earning 10 per cent interest.

After you have made your final decisions on farming activities, the first year's outcome will be given to you in the form of a 'return sheet'; it is to

be expected that the results will vary from region to region.

Use a farm accounting sheet (as in figure 12.4) to record and assess your progress.

When you have arrived at your balance for the end of Year 1, transfer it to 'cash in hand' on the accounting sheet for Year 2. You will then receive a list of forecasts and can begin your farming operations for that year. (The government may offer loans of up to 15 agrits at 20 per cent per annum interest to frontier farmers after their first year.)

After four years of farming, how have you fared?

ACCOUNTING SHEET, YEAR 1

Cash in hand: 60 agrits **Block:** ..... **Distance from town:** ..... **units**

Expenditures
Cost of land
Cost of clearing
Cost of living
Setting-up costs
Total I

Cash in hand 60
Less total expenditures
= Bank
Interest at 10%
(to nearest agrit)

Tax assessment
Gross profit
Less tax at 10%
Net profit for year

Running costs (per quarter-farm)
(a) .....
(b) .....
(c) .....
(d) .....
Total II

Gross returns (per quarter-farm)
(a) .....
(b) .....
(c) .....
(d) .....

Transportation costs
(a)
(b)
(c)
(d)

Net returns
(a)
(b)
(c)
(d)
Total net return
Plus bank interest
Less Total II
Gross profit

End-of-year balance
Bank
Net profit
Cash in hand Year 2

Total expenditures (Total I & Total II)

Figure 12.4

13

How do farmers decide what they will do?

Most of the thinking in previous studies has tended to assume that farmers will choose the type of farming activity that suits their land and situation. But is this the case?

Ask all the students in your class what sort of farming they would do if they were given a farm 300 kilometres from where they live and see what they say. How many different types of farming are mentioned?

The point is that each person has a different idea about what can be done with anything. Some geographers say that each person has a different *perception* of his environment.

Look at table 13.1, a time chart of what has happened in the Goulburn Valley since the first settlement by Europeans. Also examine table 13.2, which gives details of Shepparton's population from 1861 to 1971.

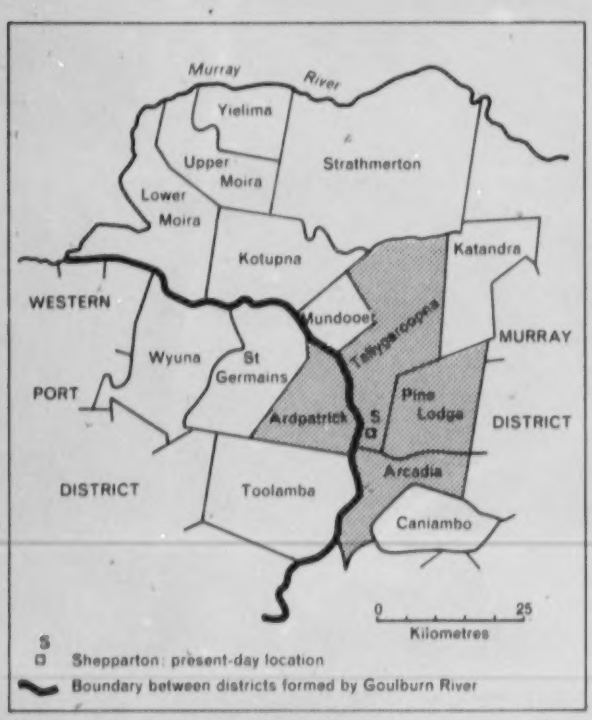


Figure 13.1: Pastoral holdings in the Shepparton area, 1835–51 (after A. S. Kenyon, Crown Lands Department of Victoria, 1932)

Table 13.1: Time chart of Goulburn Valley settlement

1841	First pastoral runs: 'Arcadia' and 'Pine Lodge' (32 375 ha) 'Tallygaroopna' (64 750 ha) 'Ardpatrick' (30 350 ha) (Figure 13.1 shows their location.)
1851	Lower valley of Goulburn River taken up with pastoral runs grazing sheep and cattle.
1860s	Exhaustion of easily-mined gold around Bendigo.
1869–71	Grant Land Acts. First of five good seasons for wheat and oats.
1872	Flour mill at Mooroopna.
1873	Flour mill at Shepparton.
1874	Most land in Shepparton district selected in 130 ha blocks ($5·00 per ha) to grow wheat and produce wool.
Late 1870s	River transport down the Goulburn and Murray the only regular method of transport available Low rainfall seasons.
1880	Railway reached Shepparton. Roads improved.
1880s	Chaffey Brothers' experiments in irrigated agriculture at Mildura and Renmark.
1881	Beginning of small waterworks and irrigation trusts. Trusts west of Goulburn obtained water from the Goulburn River; those east from the Broken River. Beginning of irrigated fruit and dairying.
1884	First large orchard in Shepparton district planted by Mason Brothers. All early orchards grew many varieties of fruit, e.g. peaches, pears, plums, citrus, apricots, nectarines, apples, vines.
1886	Irrigation Act. Goulburn Weir, Waranga Reservoir and main supply channels under construction by the Victorian government as National Works.
1888	River trade ended. Refrigerated shipments of butter to United Kingdom. Mooroopna butter factory opened. Establishment of local butter factories and creameries encouraged.
1891	Goulburn Weir completed.
1892	1200 ha of fruit trees, vines and fodder crops irrigated in Goulburn Valley. Irrigated culture still in experimental stage due to unreliable water supplies; labour shortage; absence of technically trained people to educate farmers in irrigation techniques; conservatism of farmers.
1894	Shepparton Cooperative Butter Factory.
1895–1902	Drought years.
1900	Kyabram and District Dairy Cooperative Factory.
1905	State Rivers and Water Supply Commission set up. Beginning of larger scale water control and irrigation works.
1907	Tatura Milk Products Factory. **(Cont.)**

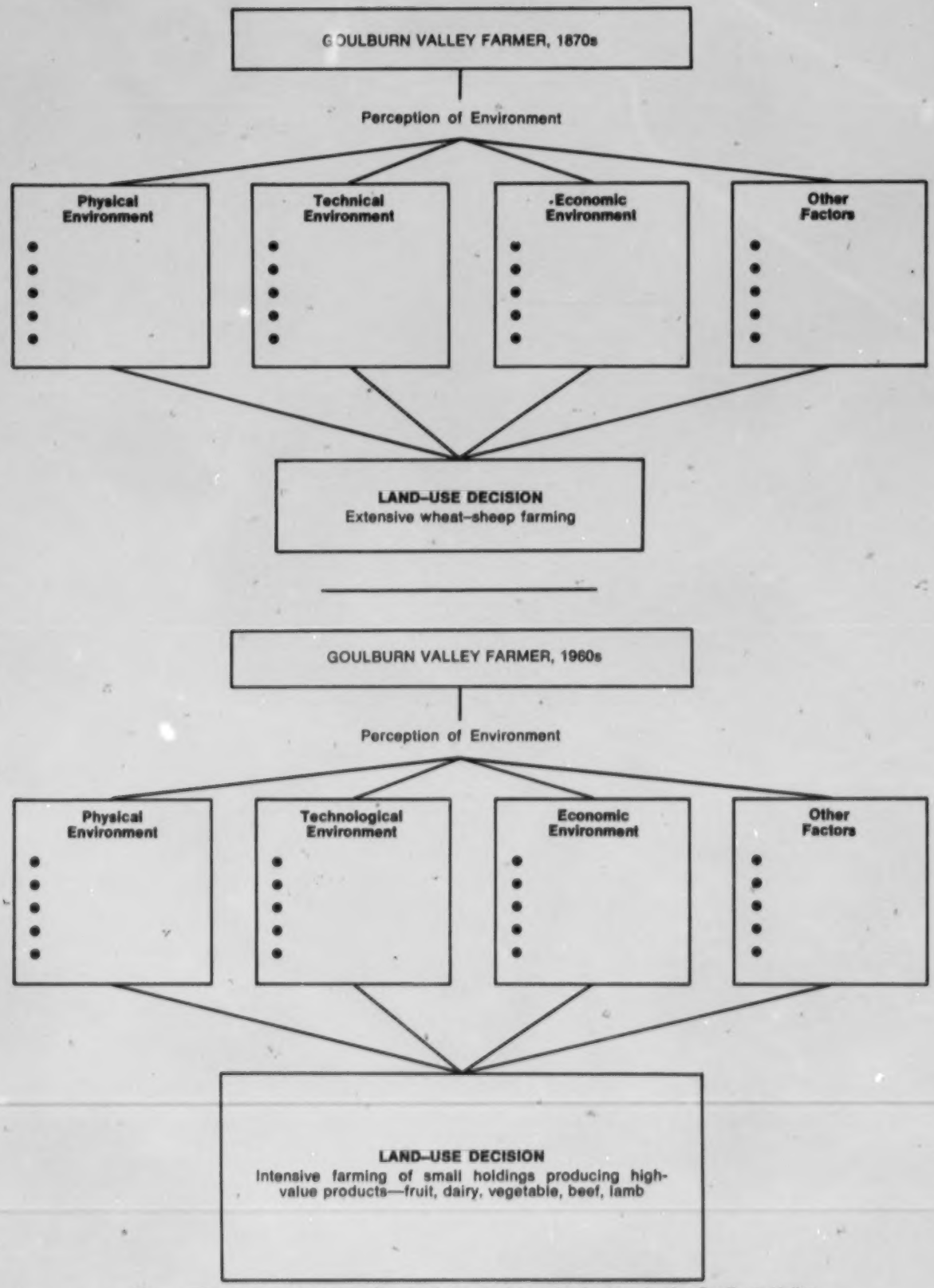


Figure 13.2: Model of comparative land-use decisions by farmers in the Goulburn Valley, 1870s and 1960s

1909–11	East Goulburn Main Channel under construction.
1910	Closer settlement scheme begun; 4000 ha of wheat and sheep land in Shepparton district acquired by Water Commission, subdivided and transferred to irrigation blocks of 8–40 ha. Smaller blocks for fruit and vegetables, larger for dairying, fat lambs and beef. End of mixed farming. Increasing specialisation in fruit and dairying.
1910	Numurkah Butter Factory.
1918	First fruit cannery—Shepparton Preserving Company (S.P.C.). Many new settlers in district were immigrants and returned soldiers.
1922	Kyabram Preserving Company.
1923	Stanhope Cooperative Dairy Company.
1926	Ardmona Fruit Products Cooperative Company at Mooroopna. Kyabram Butter Factory. Construction of Eildon Reservoir (37 750 000 m³) on Goulburn River completed.

Table 13.2: Population of Shepparton township

Year	Population
1861	30*
1879	500*
1881	770*
1901	2 100*
1920	4 000*
1933	5 698
1947	7 914
1954	10 848
1966	17 488
1971	19 409

*Estimated

What types of land use were most important in each of these periods?

1840–1870
1870–1890
1890–1910
1910–1930

In answering this question you described the *sequent occupance* of the Shepparton district.

Why did these changes occur? You may find some reasons in the answers to the following four questions:

- List the technological advances that brought about changes in land use.
- How did rainfall variability promote changes in land use?
- Make a graph of the increase in Shepparton's population, and relate it to the development of the area.
- Were the early settlers misled as to the appropriate farming systems by:
  (a) the traditions of farming in the lands from which they had emigrated?
  (b) their ignorance of long-range climatic cycles in the Goulburn Valley? (Refer back to the calculation of standard deviation in study 4.)

Any farmer settling in the Goulburn Valley area needed to assess the importance of the various aspects of the environment—physical, technological and economic—in order to decide on the kind of land use he was going to undertake. But did these various aspects affect the farmers' decisions in the same way all the time?

Throughout this area, what influences seem to have affected farmers' decisions regarding land use during two different periods: the 1870s and the 1960s?

Consider how farmers a century ago would have perceived their environment, and the kinds of things they may have felt to be important in making their decisions. Consider the modern farmer. Note the changes that have taken place in the physical, technological and economic environments, and how the farmer would assess such factors, and then relate these to the changes that have occurred in land use.

Try to complete figure 13.2, a model analysing the factors that led to completely different types of land use in the same area in these two periods.

Think about how the nature of land use in any of the farming areas mentioned in this book might alter in another twenty years' time. To what extent might changing economic, political, technological or other factors bring about differences in land utilisation? Consider the influence of such factors as higher capital costs for equipment and labour, consolidation of holdings into larger units, environmental problems, new scientific ideas, prospects of alternative markets for produce, other types of land use becoming more important, contact with other cultures, or the impact of a new social or economic philosophy.

14

Manufacturing

What do you think manufacturing is? How would you define it? Think of—or examine, if you can—a number of manufacturing firms in your area and see if they fit your definition for manufacturing. Throughout the following studies, keep your definition in mind and see how satisfactory you think it is.

The United States Bureau of the Census uses this definition for manufacturing:

1. The undertaking must be concerned with changing the form of goods (tangible commodities), not with the rendering of services.
2. Operations must be carried out in factories (buildings), and not in the field (as in the construction of buildings).
3. The process must utilise an occupational division of labour with individual workers performing separate, successive operations in the same productive process.
4. Power-driven machinery must be used.
5. The industry must turn out a uniform product (not custom work, made to a customer's order).

How far does this definition differ from yours? Look again at the manufacturing firms in your own area and see how closely they fit this definition. The five parts of the American definition could be called five *criteria* for manufacturing. As you work through this book, apply the five criteria to the various manufacturing situations, and see whether the U.S. Bureau of the Census would call each of them a manufacturing firm.

When a geographer studies manufacturing, what does he do? As you have seen previously, a geographer is especially interested in where things are and why they are there. Thus, in the context of manufacturing, we as geographers are interested in finding out where factories (*manufacturing plants*) are *located* on the earth's surface (geographical space)—see figure 14.1.

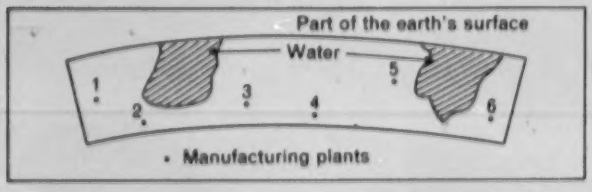


Figure 14.1: Location of manufacturing plants in space

Although manufacturing plants each have a single location, they are not isolated from one another. Goods move from one to the other, in different stages of production. These movements (*flows*) indicate *interactions* or *interrelations* between factories (figure 14.2). And so the *locations* and the *flows* can be called the *process* or the spatial system of manufacturing, which we are to describe and explain.

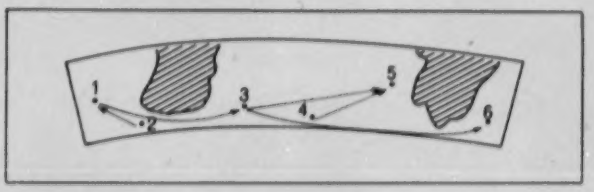


Figure 14.2: Interactions of manufacturing plants in space

Why are factories located where they are?

Factories are located in particular places for many reasons. Some of these are purely:

1. ***economic***—what is called the *least cost aim;* that is, the factory owner is trying to find the location that will allow him to lower his costs and thus raise his profits; or purely
2. ***behavioural***—what is called the *personal satisfaction aim;* that is, the factory owner is aiming to satisfy his own objectives or ideas; but the reasons may be
3. a ***combination*** of both.

Imagine yourself as a location consultant, an expert in deciding on the best factory location, for a motor car manufacturer. Where would you locate the factory? Let's think about a car factory.

On the right-hand side of figure 14.3 is an arrow showing something coming out of the factory; this is obviously the car, the *finished product.* Where would it be going? Probably to someone's showrooms to be sold—where and to whom it is sold is the *market.* Let's now think about the left-hand side of the diagram. What would come into the factory in order for cars to be produced? Firstly, all those materials—steel, rubber, glass, paint, spark plugs, etc.—that are needed to make a car. Where would these come from? Look back at figure 14.2—what

name is given to this movement? We classify all these 'materials-to-be-used' as *raw materials*. How are all the raw materials to be manufactured into a car? This requires three things, two of which come into the factory and one of which is already there. The two *inputs* are the workmen (*labour*) and the *power* that keeps the *machines* going; the machinery is what is already there inside the *building*, and the building and the machinery make up the *plant*.

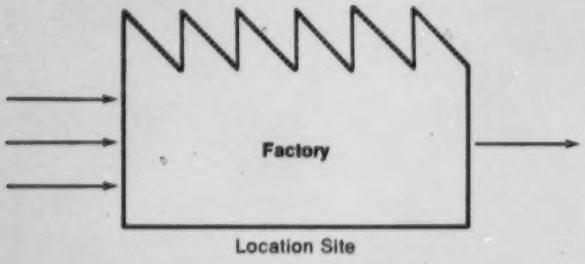


Figure 14.3

Thus a manufacturing system is made up of a number of *inputs*, a *plant* at a *location*, and a number of *outputs*. What connects the inputs, the plant and the outputs? Obviously *transport* is the force that links all elements of the manufacturing system together.

Knowing all this, what sorts of factors would you, as a location consultant, consider in locating the car factory? Basically, you want to locate at a place where the manufacturer can produce the car as cheaply as possible. Look at figure 14.3 and the discussion of what makes up the manufacturing system. What sorts of costs are going to affect the final price the manufacturer can ask for each finished product? Some costs will only be paid once. Others—*running costs*—will be continually being paid. Make a list of each type of cost.

As all these costs will affect the price of each car, you will try to decide where the cheapest place to locate a factory will be in relation to all these factors and to what your competitors will do; as all these factors are rarely at the one place, transport becomes very important in your final decision.

Later on you will have an opportunity to decide where to locate a factory in a place called Corbland. But before you do this, you will examine some actual factories and try to work out why they are where they are.

15

Manufacturing in Geelong

What sorts of situations encourage manufacturing?

In study 14 you tried to work out where, as a locational expert in a manufacturing firm, you would locate a factory. You found that you had to take into account a number of factors:

- Raw materials
- Transport from the raw materials source to the factory
- Transport from the factory to the market
- Labour
- Capital to build the plant
- Competitors' locations and prices.

Now you are to look at what a manufacturer does in a particular situation. Geelong is a city on Corio Bay off Port Phillip Bay in Victoria (figure 15.1).

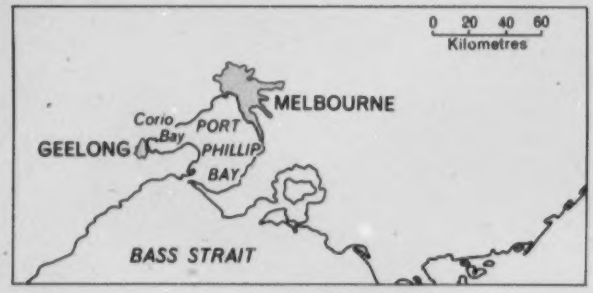


Figure 15.1: Geelong—location map

Look at the data on Geelong in tables 15.1 to 15.6. Why might you, as a manufacturer, be tempted to locate your factory in Geelong if you were presented with this information?

Recently a large number of manufacturers in Geelong were asked why they had located their factories there. Their answers are contained in table 15.7. Which of the reasons they gave might be advantages of Geelong in general, as indicated by tables 15.1–15.6? This would indicate, perhaps, why these manufacturers chose to establish themselves in Geelong.

Write an account of your opinion of Geelong as a city in which to locate a factory. Do you think it is suitable? What else, as a location consultant, would you want to know before recommending Geelong to a manufacturer?

Table 15.1: Population growth in Geelong, 1949–71

Year	Population	Actual growth	Percentage growth
1947	53 000	—	—
1954	72 595	19 595	37%
1961	91 777	19 182	26%
1966	105 059	13 282	14%
1971	115 047	9 988	9%

Table 15.2: Growth rate indicators for Geelong: percentage increase from 1960/61 to 1967/68

Indicator	Geelong	Melbourne	Victoria
Factories	10·3%	7·6%	4·8%
Local employees	18·7%	18·0%	16·2%
Wages and salaries	67·0%	62·8%	60·5%
Production	85·5%	71·5%	70·6%
Land, plant and buildings	88·2%	70·4%	64·0%

Table 15.3: Development of population and industry in Geelong

Date	Population	Industries established between dates	Totals
Before 1900	46 400	17	17
1901	51 320	2	19
1911	42 403	0	19
1921	36 170	1	20
1933	39 223	6	26
1947	53 000 (est.)	5	31
1954	72 595	6	37
1961	91 777	7	44
1966	105 059	11	55
1971	115 047	4	59

Table 15.4: Number of factories in Geelong

1947	257
1954	326
1961	490
1966	524
1968	558
1971	568

Source: Commonwealth Bureau of Census and Statistics

Table 15.5: Population ranking of some Victorian cities, 1900–71

Census Year	Melbourne		Geelong		Ballarat		Bendigo		Warrnambool		Shepparton	
	Population	Rank	Population	Rank	Population	Rank	Population	Rank	Population	Rank	Population	Rank
1901	496 079	1	51 320	2	25 801	4	42 540	3	6 660	5	—	—
1911	593 237	1	42 403	2	28 518	4	39 417	3	7 010	5	3 000	7
1921	782 979	1	36 170	3	38 500	2	33 170	4	7 739	5	4 000	6
1933	991 934	1	39 223	2	37 411	3	29 131	4	8 906	6	5 698	7
1947	1 226 409	1	53 000	2	40 181	3	30 779	4	9 993	7	7 914	8
1954	1 524 111	1	72 595	2	48 030	3	36 918	4	10 850	5	10 848	6
1961	1 911 895	1	91 777	2	49 027	3	37 412	4	15 702	5	13 580	6
1966	2 110 168	1	105 059	2	56 290	3	42 208	4	17 499	6	17 506	5
1971	2 394 117	1	115 047	2	58 620	3	45 936	4	18 684	6	19 410	5

Source: *Victorian Year Books*

Table 15.6: Establishment of services and establishment of manufacturers, Geelong

Services	Establishment of services	Manufacturers established
Gas	1858	Before: 2 After: 57
Electricity	1920s	Before: 19 After: 40
Water (industrial use)	1900s	Before: 17 After: 42
Utilities overall	—	Before: 21 After: 38
Maintenance	1940–67	Before: 29 After: 30

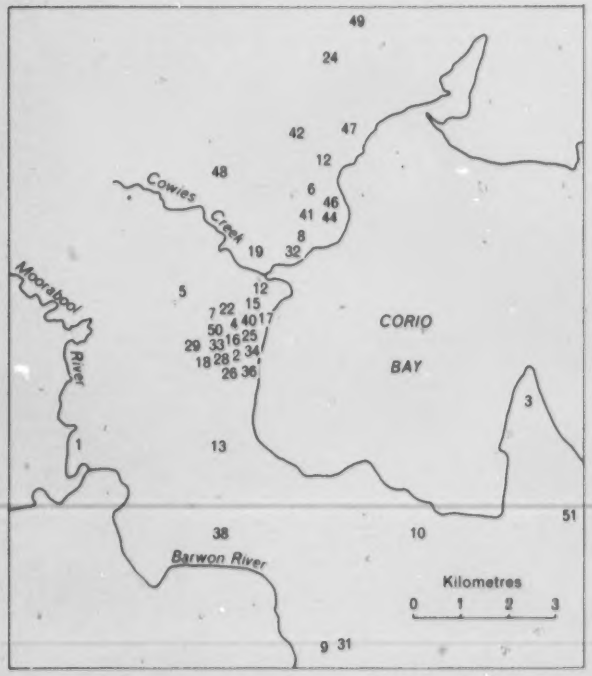


Figure 15.2: Location of factories listed in table 15.7. Numbers 14, 20, 21, 23, 30, 35, 37, 39, 43 and 45 have changed name or closed down since the survey

Where in a city may manufacturers locate factories?

Once a manufacturer has decided to locate in Geelong, what is the next step? Whereabouts in Geelong, on what area of land, is the factory going to be located? Look through table 15.7 again. Which of these factories appear to need some special type of land, according to this list?

Where are factories located in Geelong? There are two methods of answering this question:

1. Make a map of all factory locations in Geelong.
2. Use statistics to make special types of maps of manufacturing in Geelong.

First method

Figure 15.2 shows the location of all factories listed in the survey. By reference to table 15.7, trace a map of those factories needing some special type of land.

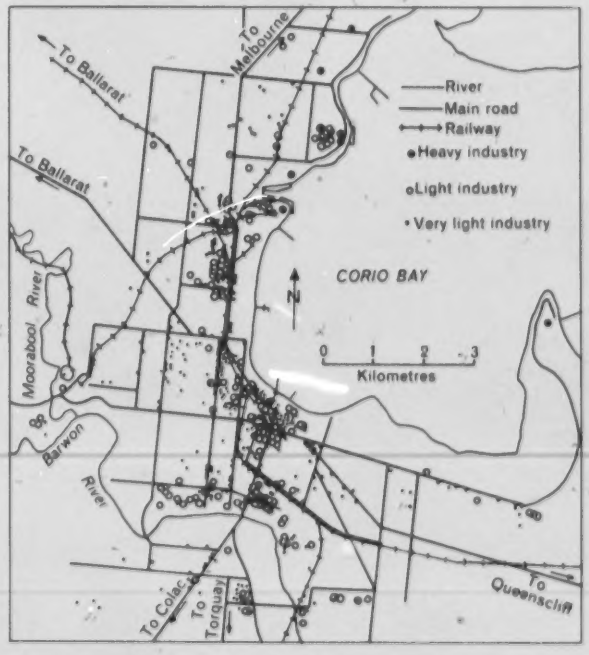


Figure 15.3: Location of factories in Geelong, by factory type

Table 15.7: Opinions of manufacturers in Geelong on reasons for factory location
(factors influencing location ranked in order of importance)

	Manufacturer	Year set up	Availability of raw materials	Labour supply	Access to markets	Port locality	Cost of power	Cost of fuel	Transport facilities	Transport rates and costs	Health of population	Size of land available	Water supply	Price of land	Attraction of other industries	Transport efficiency	Historical reasons	Availability of semi-processed products	Capital and finance	State Gov. inducements	Necessity for Vic. location		
1	Aust. Portland Cement Co.	1890	1	2																		Cement	
2	Albion Reid	1915	1	2																		Tar, bitumen, asphalts, creosote, tar-oil, pitch	
3	Alcoa	1963	2	8	1	3	4	5	6	7	9	10										Aluminium	
4	Anderson	1961	2	4	1								3									Steel engineering plates	
5	Angus & Taylor	1954	2	3	1																	Steel fabrications	
6	Birmid	1956		3	1	2								4	5							Automotive castings	Pig iron—N.S.W. Scrap—Melb. Coke—Newcastle, Launceston
7	Baldasso	1953	2	7	1			3	4	5						6						Steel fabrications	
8	Bodycraft	1967	2	3	1										4							Sheet metal work	
9	Brintons	1960	2	7	1	3	5			6			4		8							Carpets	
10	Cheetham	1900	1	2																		Salt	
11	Coca Cola Bottling	1965		2	1																	Softdrink	
12	Corio Distilleries	1927		3	1								2									Spirits	
13	Donaghy & Sons	1852															1					Rope, string	
14	Daolet	1965		3	1	2									4							Boilers, hoppers, chutes, tanks	
15	Diemoulders	1933	2	6	1	3						7	5		2			4				Castings, dies, blocks	
16	Ettrick Woollen Mills	1947	1	3									2		4							Woollen textiles	
17	Federal Woollen Mills	1923	2		1	3	5		6	7			4		9	8						Cloth, clothing	
18	Fletcher Chemicals	1965	2	3	1										4							Industrial chemicals	
19	Ford Motor Co.	1925		8	1	2			4	5		10	3	11	7	6			9			Sheet metal & machined components for cars	
20	Geelong Flour Mills	1900	2		1	3			4													Flour	
21	Geelong Woollen Mills	1855–1870	2	8	1	3			5	6			4		9	7						Cloth, clothing, blankets	
22	Golding Brakes	1957		9	1		4	5	6	7			3		10	8		2				Brakes for vehicles	
23	Goodchild Shoes	1942	2	7	1				4	5			3			6						Shoes	

24	Grinters	1959		5	1			2	3							4						Steel fabrications	
25	Geelong Gas Co.	1858	2	3	1						4				6					5		Gas	
26	Haigh & Taylor	1953	2	3	1										4							Woollen goods	
27	Hancock	1962	2	3	1							4		5	6							Cabinets	
28	Henderson's	1937		8	1	2		4	5	6				9		7		3				Springs, mattresses	
29	Hotchins	1960		6	1	2			3	4					4	5						Industrial patterns	
30	Humes Pipes	1951	2	5	1								3		6	4						Pipes	
31	Huyck	1966	2	10	1	3	6		7	8			5	11		9		4				Industrial felts	
32	International Harvester	1939	2	4	1									5				3				Tractors, machinery	
33	Lindex Chemicals	1964	2	3	1										4							Industrial chemicals	
34	Milburn Knitting Mills	1965		2	1																	Clothing, blankets, rugs	
35	Minrad Electronics	1957		2	1										3							Electronic equipment	
36	Monier Belmont	1948	2		1										3							Tiles	
37	Multi-Hue Agricultural Machinery	1935		3	1										4			2				Hoes, tractors, lawnmowers	
38	Newtown Tile	1947	2		1										3							Tiles	
39	North Shore Distributors	1966		3	1	2									4							Manufacture of distributors for motor vehicles	
40	Pilkington Brothers	1937		3	1											2						Glass	
41	P.&C. Steel	1963	2	3	1										4							Steel fabrications	
42	Pelaco	1965		4	1				2	3												Shirts	
43	Phoenix Fuse	1967		2	1										3							Fuse ignition systems	
44	Phosphate Co.	1926	2		1	3								4								Fertilisers	
45	Primal Chemicals	1966	2	5	1	3							4	6	3							Industrial chemicals	
46	Ryland Bros.	1953		3	1	2								4								Wire, nails, reinforcement	
47	Shell Refining Co.	1950		5		1			4			7	3		8			2		6	9	Fuels, oils, bitumen, acid	Crude oil—Gippsland, Barrow Is., Kuwait, Iran, Syria, Basra, Qatar
48	Sunicrust Bakeries	1964	2		1								3		4							Bread	
49	Tip Top Bakeries	1968	2		1								3		4							Bread	
50	Tarax	1959			1								2									Softdrink	
51	Winchester Western	1969		6	1	2	4	5					3	7								Rifles, pistols, ammunition	
	TOTALS		30	42	45	18	6	6	14	12	2	5	18	10	28	12	1	7	1	2	1		
	Importance Rating		3rd	2nd	1st	5th	12th	12th	7th	8th	15th	14th	5th	10th	4th	8th	17th	11th	17th	15th	17th		

Table 15.8: Classification of industrial types

Type of industry	Goods produced	Land area	Employment	Material used	Equipment	Examples
VERY LIGHT	Low in weight and cost. Everyday articles.	Less than 0·5 hectare	Less than ten	No 'raw' materials. Some processing already done.	Little—only simple machinery	Printing, wood-working, small car repairers
LIGHT	Dearer. Less used directly by consumer.	Less than 4 hectares	More than ten	Some raw and bulky materials.	More specialised and expensive	Larger engineering workshops, textiles
HEAVY	Dear and heavy goods in large quantity.	More than 4 hectares	More than 200	Bulky, heavy, raw materials.	Specialised, complex, expensive	Automobiles, oil refining

When people try to understand something, they devise classifications in order to simplify all the facts that can be discovered. In manufacturing, the classification shown in table 15.8 is often used.

Figure 15.3 shows the location of *all* factories in Geelong classified under these headings. Describe the differences in number and distribution of factories between this map and the previous map. From figure 15.3, you could make tracings of the factories of each type to show more clearly the differences in distribution of heavy, light and very light industry. Do the different types have different distributions? What reasons can you suggest to explain this?

Second method

Statistics are often used to show the distribution of a number of different features. Look at the map showing the suburbs of Geelong (figure 15.4) and table 15.9 listing the number of factories in each suburb. Draw a map combining this information, using bars of different sizes to represent the numbers of factories in the various suburbs. Does this map look like figure 15.3?

Table 15.9: Number of factories in each suburb, 1968

1.	Corio	8
2.	Norlane	21
3.	North Shore	19
4.	Bell Post Mill	—
5.	Bell Park	5
6.	North Geelong	71
7.	Hamlyn Heights	—
8.	Herne Hill	4
9.	Manifold Heights	4
10.	West Geelong	74
11.	Drumcondra	—
12.	Newtown	6
13.	Fyansford	7
14.	Chilwell	44
15.	North Highton	5
16.	South Highton	
17.	Belmont	19
18.	East Belmont	21
19.	Geelong	160
20.	South Geelong	46
21.	East Geelong	21
22.	Breakwater	7
23.	Thomson	4
24.	Newcomb	10
25.	Moolap West	—
26.	Whittington	—
27.	Point Henry	3

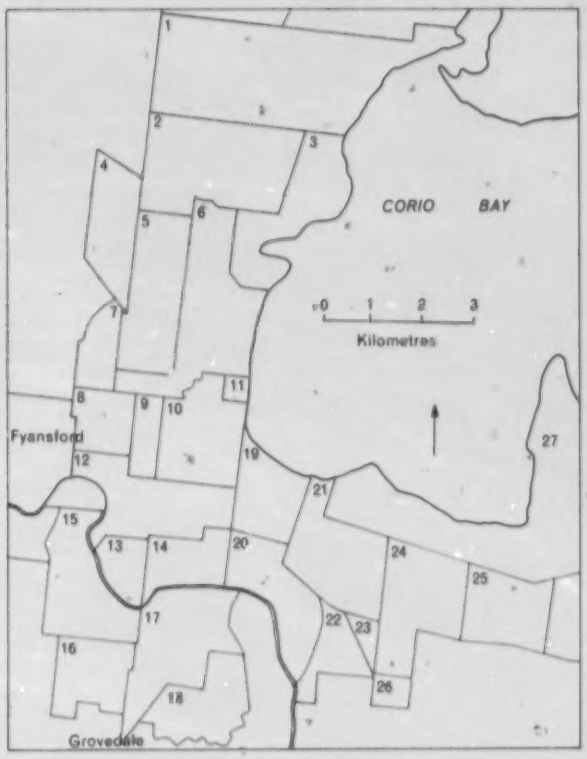


Figure 15.4: Suburbs of Geelong (for key, see table 15.9)

So far, then, you have looked at a map of all factories, classified as 'heavy', 'light' and 'very light', and made a map of the number of factories in each suburb. Can you find special types of factories in special places in Geelong? This is an important question, and answering it involves a great deal of work.

The best way to do this is for each person to undertake part of the work. First you need three groups—one to examine 'heavy', one for 'light' and one for 'very light'. Now refer to table 15.10, listing by suburb the numbers of factories of particular

Table 15.10: Factory types by suburbs, 1968

| SUBURB | TYPE AND CLASSIFICATION OF INDUSTRIES | | |

types within these classifications; in each group every person should make one or more maps (depending on the number of persons), so that when the results are pooled each group has produced maps of all the particular types within the general classification for which they are responsible. Then each of the three groups should present a report answering these questions:

1. Are particular types of manufacturing important in each general classification?
2. Do you find particular types of manufacturing in particular areas?

How can all this description be explained? Why are factories located in particular areas? The following hypotheses might be suggested.

- 'Very light' factories are located close to where they sell their goods, or close to their labour supply.
- 'Heavy' factories are located on the outskirts of the city.
- Those factories which need bulky raw material are close to port areas.
- Areas with high-value housing and occupational status have very little manufacturing.
- Most manufacturing is found on relatively flat land.
- Small factories (light industrial) are usually found in densely populated areas.

Examine your maps and try to work out other hypotheses. Now you need to see whether you can find evidence to support the hypotheses that have been put forward.

Each of the above hypotheses contains two parts. One part specifies a type of manufacturing. The other part states something about location; this is supposed to help explain the type of manufacturing. Figures 15.5–15.21 contain a great deal of information about the locational aspect. Compare what you have discovered about manufacturing with the information in these maps and photographs, and see if you can confirm any of the suggested hypotheses or any of your own devising.

In the preceding activities, you looked at the distribution of factories in Geelong and considered possible reasons for this distribution. If you now examine some particular cases, you may be able to see whether these ideas are relevant in real situations.

Figure 15.22 shows the location of the four factories to be studied in detail.

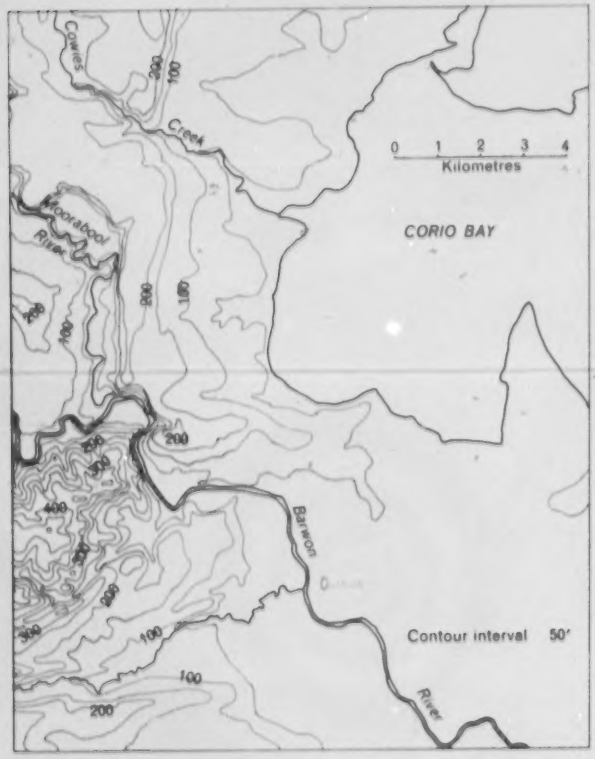


Figure 15.5: Geelong—relief and drainage

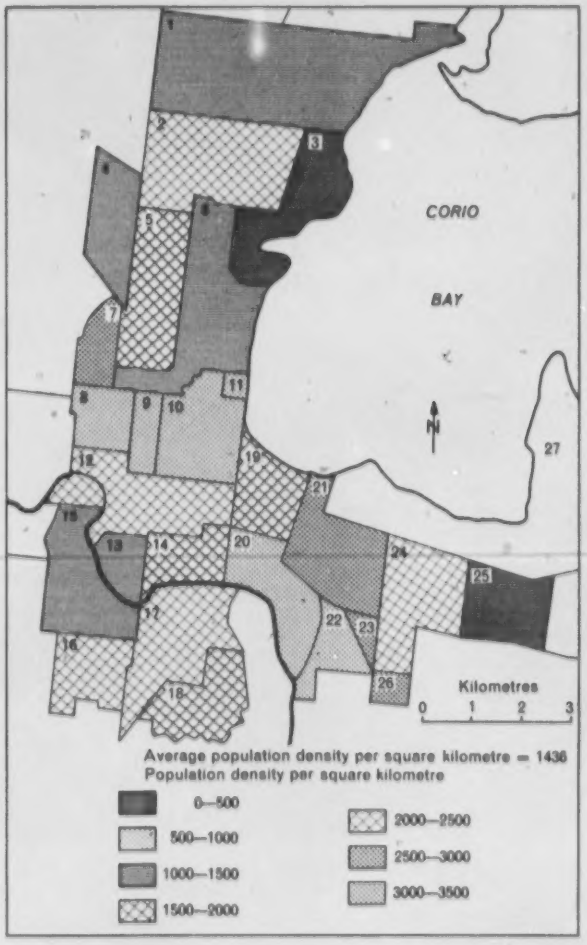


Figure 15.6: Geelong—population density by suburb, 1971

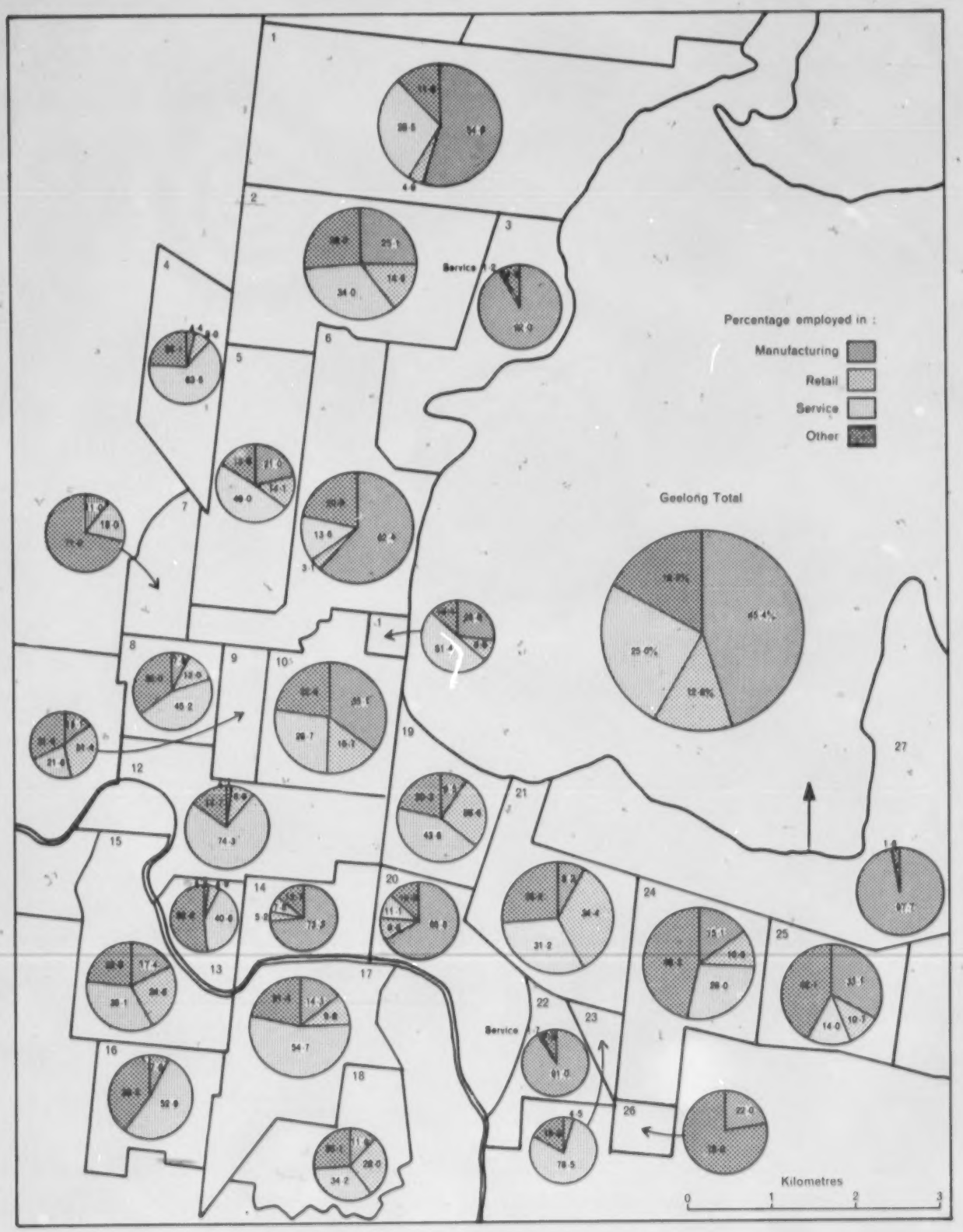


Figure 15.7: Geelong—type of employment by suburb, 1970

Figure 15.8: Port of Geelong, 1971

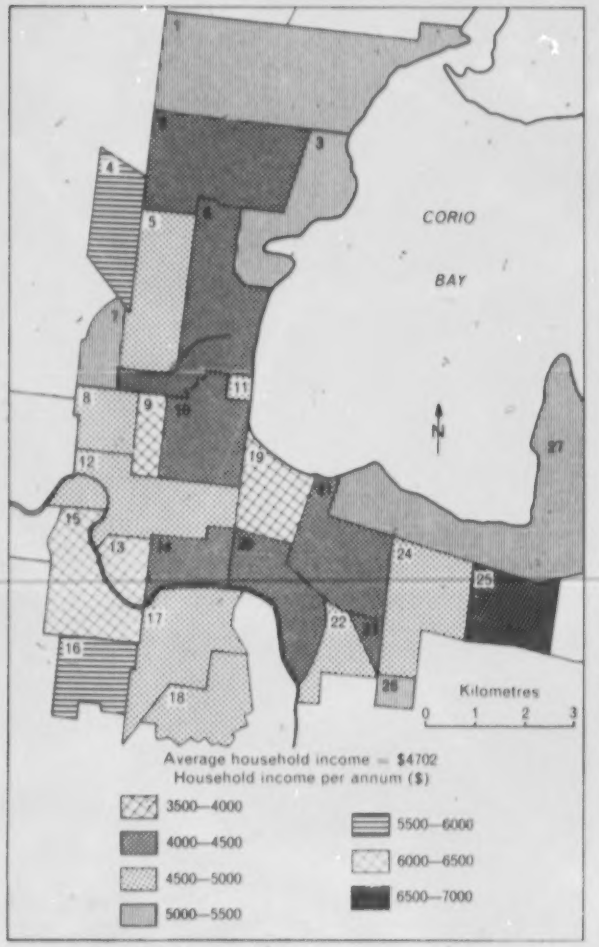


Figure 15.9: Geelong—household income per annum, by suburb, 1970

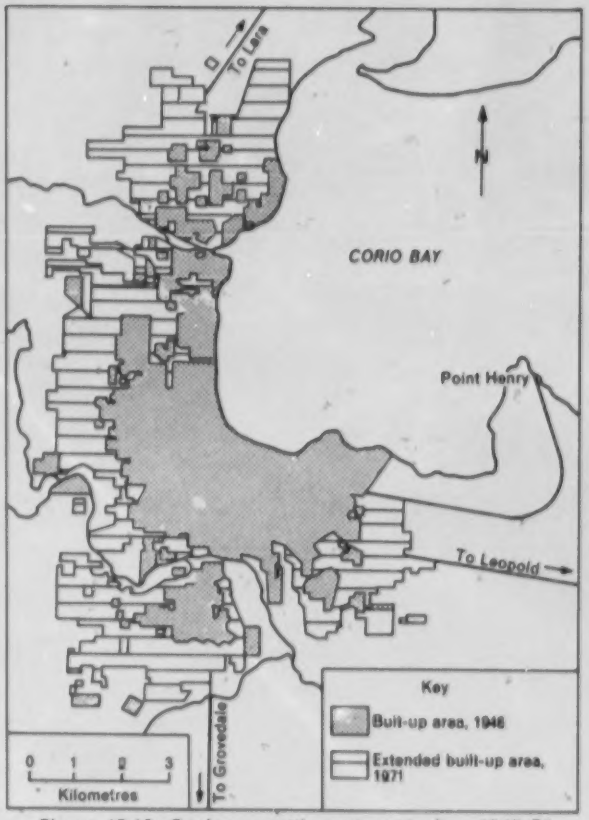


Figure 15.10: Geelong—settlement expansion, 1946–71

Figure 15.11: Looking north over wheat silos and Corio Quay, with Shell oil refinery at top right. Compare with figure 15.8

Figure 15.12: Looking west from East Geelong, with the Central Business District in the centre and the Fyansford cement works in the background

Figure 15.13: Looking north over newly developing Grovedale towards Belmont (see figure 15.4). Note the farmland at the top right along the Torquay road—what type of farming might this be?

Figure 15.14: Housing Commission homes in Norlane

Figure 15.15: Homes in Highton

Figure 15.16: Homes in West Geelong

Figure 15.17: Housing in Newtown

Figure 15.18: Flats in Drumcondra

Figure 15.19: Oblique aerial view of Geelong's C.B.D.

Figure 15.20: Ground view, Geelong C.B.D.

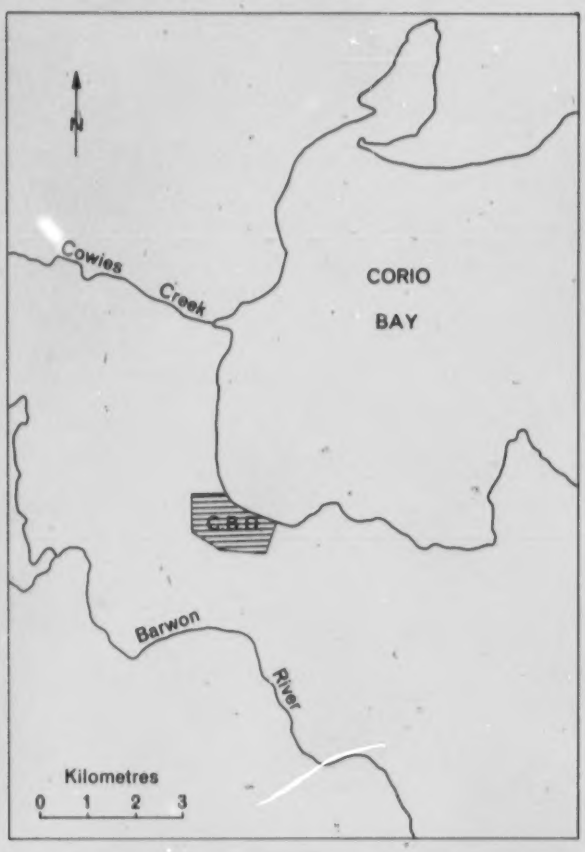


Figure 15.21: Location of Geelong C.B.D.

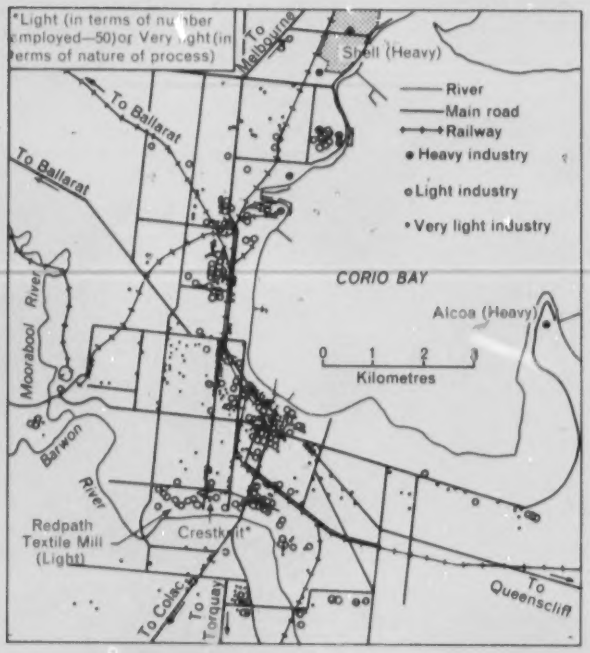


Figure 15.22: Location of four industrial case studies

A: The Shell refinery, Corio

DATA

Site history

The land for the Shell refinery was purchased from the Geelong Harbour Trust in the late 1940s. Before World War II, Shell had intended building a new refinery in Borneo, near the (now Indonesian) oilfields; there the crude oil would have been refined, the finished products then being shipped to south-eastern Australia.

Changes in circumstances (political instability) and economic reasoning (locate at market) led to a search for a suitable site in Victoria. (Shell had bought the small Clyde Refinery in Sydney in 1927.)

Several sites were considered:

1. *Westernport*—main advantages in 1947:
   - deep water
   - near Melbourne
   - cheap land

The main disadvantage was the lack of a labour supply, and this ruled Westernport out.

2. *Point Henry*—main advantages in 1947:
   - close to Melbourne
   - cheap land
   - labour supply at Geelong

The main disadvantage was that a pipeline would have to skirt the urban area of Geelong to reach Altona.

3. *Corio*—main advantages in 1947 were as for (2), *plus*
   - Promise by Harbour Trust to have channels dredged to 11 metres by early 1950s to cater for 30 000–50 000 tonne tankers. (In 1947 it was not envisaged by Shell's planners that tankers of the 1970s would be in the order of hundreds of thousands of tonnes.)

A disadvantage today is that the Rip (the entrance to Port Phillip Bay) will never be able to be dredged (it has a solid rock bottom). Therefore, neither Altona nor Geelong will ever be able to receive tankers over 50 000 tonnes; hence the transition by Shell to receiving more and more crude oil from Bass Strait by pipeline, and consequently less use of port facilities.

The location decision was made overseas (Shell is 60 per cent Dutch-owned, 40 per cent British). The Harbour Trust offered the land to Shell cheaply (price not disclosed) and promised to improve the harbour. In 1952 construction of the refinery began, and production started in 1954.

Do you think the company would choose this site today? Why?

Inputs and outputs

Refer to tables 15.11 and 15.12. The 1969 and 1970 figures for crude oil inputs are abnormally high, rather than 1971 being low. In 1969 and 1970, Shell refined a lot of crude for other companies, which otherwise could not have fulfilled their contracts.

Figure 15.23: The Shell oil refinery, Corio

Other inputs include sea water (for cooling) and 4 500 000 litres of fresh water daily (for production of steam for on-site electricity generation).

What changes had occurred by late 1973 to alter the system as shown here?

Table 15.11: Crude oil input (million tonnes) and sources

1968	3·80	Abu Dhabi Kuwait
1969	4·75	Basra Qatar
1970	4·20	Syria Barrow Island
1971	3·67	Bass Strait

Table 15.12: Output, 1971 (tonnes)

Motor spirit	1 024 000	
Dieseline	758 000	
Kerosene	457 000	
Furnace oil	953 000	
Lubricating oil	94 700	
Bitumen	37 000	
Oil for own use (electricity gen.)	406 000	(not included in input)
L.P.G.	57 400	
Gas	48 000	
Acid	57 000	
Miscellaneous	183 000	
Total	4 075 100	

Figure 15.24: The Shell refinery's distribution area

Distribution of the products

The Geelong refinery supplies all of the Shell products for the whole of Tasmania (by coastal tanker) and for western Victoria (see figure 15.24).

The refinery supplies over 90 per cent of all petroleum products consumed in the Geelong urban area. All major petrol companies have distribution centres located about a kilometre from the refinery, linked to it by pipeline.

Pollution control

- Air pollution:

1. Sixty per cent of the crude oil for this refinery is Australian crude ('sweet' crude, having a low sulphur content); therefore, as the percentage of local crude oil refined increases, the pollution level decreases. (Middle East crude is 'sour', having a high sulphur content.)
2. The installation of higher chimney stacks means that fumes are dispersed more quickly. The highest one now is 40 metres tall.

- Water use:
  The plant is changing over to air-cooled apparatus rather than water-cooled, which can cause thermal pollution of the bay.
- General:
  Half a million dollars are spent annually on pollution control at the refinery.

B: Crestknit Leisure-knit

DATA

- Type of activity: making-up of knitted garments (mainly cotton).
- Location: Fyans Street, Chilwell (see figures 15.22 and 15.25), and situated among private houses in an area zoned as 'light industrial' in the Geelong Town Plan (figure 15.26).
- Size of block: 13 metres by 40 metres.

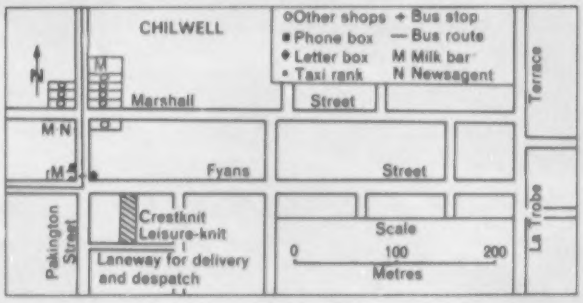


Figure 15.25: Location of the Crestknit factory

Site history

In 1969, Crestknit were experiencing some trouble in obtaining suitable supplies of female labour to make up knitted cotton garments in their Melbourne factory. Among the attractions offered by a factory location in Geelong were the availability of plenty of female labour (Geelong has a high percentage of female unemployment), and a travelling time of only one-and-a-half hours from the Melbourne factory by road.

Crestknit's directors sought to start experimentally in Geelong in a small way. They purchased a vacant warehouse building in Fyans Street, Chilwell, for several reasons:

1. They didn't want to outlay money for building costs.
2. The building was 'reasonably' priced.
3. The building was centrally situated (3 kilometres from Geelong G.P.O.) on a main intersection (Pakington and Fyans Streets). This was advantageous for ease of stock delivery from Melbourne, and for the facilities available to the labour force (bus route, nearby shops, etc.).

Figure 15.26: The Crestknit factory

On 15 September 1969, production started under manager Mr Neil Combridge, in the 7·5 by 15 metre building, with nine sewing machines and nine girl operators.

Today

There are an average of fifty employees: a manager, a junior boy, and the remainder women operators (60 per cent of whom are married and 30 per cent of whom are under twenty-one years). The building has been enlarged to the limits of the block (except for a small back-yard for incinerator, etc.), and is now brick-faced.

Inputs

Unspecified numbers of lays are brought by truck from the factory in Collingwood, Melbourne (usually weekly). (A lay is a large piece of square knitted material, which is cut and made up into a garment at the Chilwell factory.)

Outputs

One thousand dozen made-up garments are produced weekly, comprising women's undergarments, men's undergarments, T-shirts, skivvies, etc. These are sent back by truck to Collingwood.

Processes

1. *Cutting* the lays into shapes with an electric 'knife'
2. *Sewing* the parts together on machines
3. *Ironing* the garment when finished
4. *Examining*, and *packing* in plastic bags
5. *Despatching* in cardboard boxes by truck

C: W. R. Redpath and Sons

The Redpath textile mill (figure 15.27) is one of a number of textile factories in Geelong. Figures 15.28–15.31 show some of the other enterprises.

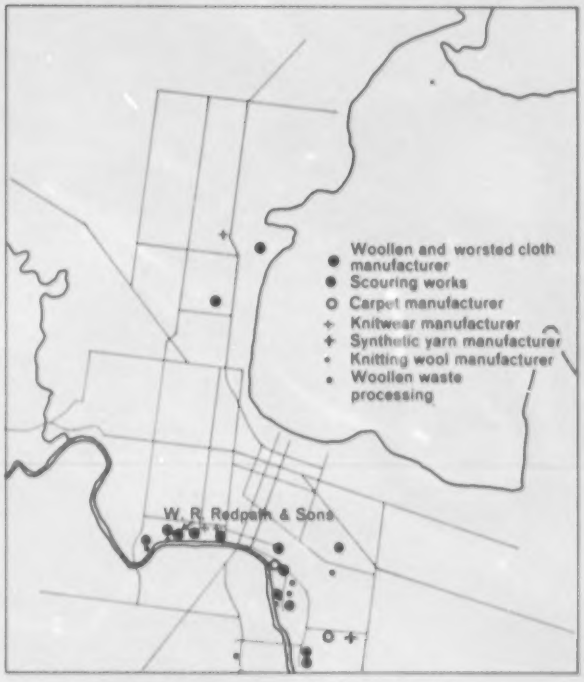


Figure 15.28: The textile industry in Geelong

Examine figure 15.28. What do you notice about the pattern of distribution of textile factories in Geelong?

Compare figures 15.27, 15.30 and 15.31 with figure 15.29. How does the appearance of the various factories differ? If you were an architect drawing up plans to modernise a textile mill, what details would you want to know?

Figure 15.27: W. R. Redpath and Sons' woollen mill

Figure 15.29: Brinton's Carpets, Breakwater

Figure 15.30: Woollen mills along the banks of the Barwon River

Figure 15.31: One of Geelong's riverbank textile mills

Site history

The textile mill shown in figure 15.27 has been operating since the 1930s at the location shown in figure 15.32.

Figure 15.32: Location of the Redpath mill

The mill is situated almost on the river bank. It was constructed in 1891 as a proposed paper mill, but never came into operation as such. Instead the building remained a 'white elephant' until April 1934, when a Scotsman, W. R. Redpath, purchased it. (Redpath had come to Australia as a child, and had gained experience as assistant manager at Lobethal Woollen Mills, South Australia, then manager of Myer Woollen Mills, Ballarat, and Godfrey Hirst Mills, Geelong.)

The location had the advantages of:

- availability of river water (which had to be softened) for the boilers and for dyeing, and for waste disposal (although note that, now, no textile mill located near the river is permitted to use the water for any of these purposes)
- low municipal rates
- adequate transport facilities.

The study of the Crestknit factory suggested that the availability of female labour was a factor that made Geelong attractive to such an enterprise. Did this factor affect this mill?

Examine figure 15.33. Does this pyramid provide evidence of a dependence on female labour? What is the difference between the male population structure and the female population structure? What explanations would you suggest for your findings?

Figure 15.34 shows the locations of the homes of the mill employees. Describe the distribution of the homes. What explanations would you suggest for this? Is *distance* enough? (The data contained in figures 15.6, 15.7 and 15.9 might assist you.)

Figure 15.33: Population pyramid of Redpath employees

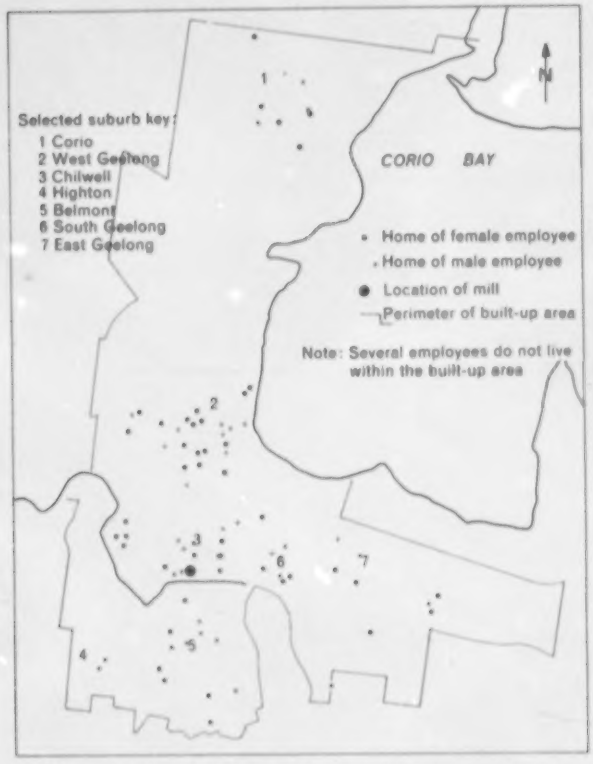


Figure 15.34: Locations of homes of Redpath employees

If figure 15.34 shows where each employee travels to and from each day, can you imagine the problems created by traffic congestion at peak times, when all the mills 'knock off'? Figure 15.35 shows the volume of traffic during an afternoon at an important intersection near the mill. What traffic problems exist at this intersection, as shown by the graph? How could the problems be overcome? Might the solutions you suggest in turn cause other problems?

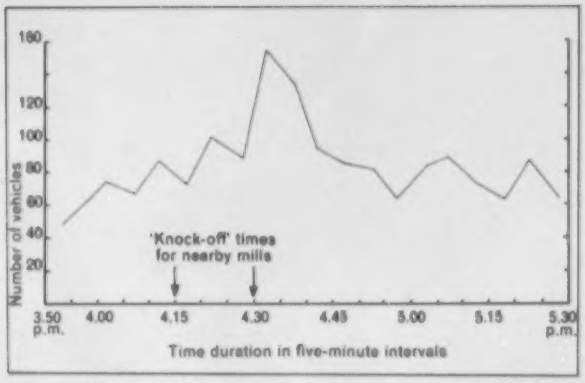


Figure 15.35: Traffic survey at Fyans Street–Pakington Street intersection (figure 15.32)

Multiply this intersection by at least fifty others (most with no traffic lights), and you will have some idea of the traffic problems caused by Geelong's industries.

How does the factory operate? You have already seen some details of the labour input. Table 15.13 shows the raw materials and their sources.

Table 15.13: Inputs to mill

Materials	Amount	Immediate source
Fine crossbred wool	45 000 kg	Melbourne brokers*
Merino wool	9 000 kg	" "
Shetland wool	21 750 kg	" "
Fine lambswool	32 500 kg	" "
Nylon fibre	1 600 kg	" "
Rayon fibre	2 250 kg	" "
Upholstery yarn	3 500 kg	" "
Worsted yarn	1 350 kg	Geelong mills
Dyes, chemicals	$23 500	Melbourne importers
Fuel oil	$2 900	Geelong
Blending oil	$2 800	Melbourne
Electricity	$7 900	S.E.C.

*'Melbourne brokers' means that the wool is purchased by Melbourne brokers from sales in several cities, including Geelong

Processing of the wool

1. Wool purchased by Melbourne brokers from sales in several cities, including Geelong. Scoured and carbonised by local scouring firms, and delivered clean to mill.
2. Dyeing and blending to obtain exact shade.
3. Carding—soft fibres formed.
4. Spinning—fibres spun into thin yarn.
5. Designing—looms pre-set to weave in a particular design. Yarn prepared on a warping machine.
6. Weaving of the cloth.
7. Mending—rectifying of any faults that developed during weaving.
8. Pieces sent away to be 'finished', that is, washed and otherwise treated at local finishing plants.
9. Pieces returned to mill for despatch to customer (usually a Melbourne clothing or upholstery manufacturer) by truck.

Table 15.14: Outputs of mill

Goods produced	Amount	Immediate destination
Woollen cloth (for clothing, etc.)	64 000 m	Melbourne agents
Upholstery fabric	22 850 m	" "
Worsted cloth	2 750 m	" "
Travelling rugs (woollen)	2000 rugs	" "
Commission spinning:		
Shetland yarn	20 400 kg	Melbourne mills
Lambswool yarn	31 300 kg	" "

Refer to table 15.14 for the mill's outputs. Make a map of the inputs and the outputs in relation to the location of the factory. How does your map help explain the location?

You were earlier given an explanation of the benefits deriving from the mill's location when it was originally established. However, one of these advantages no longer applies. Do any of the other explanations satisfy you? Do either the inputs or the outputs help explain the location? Why do you think the factory is in Geelong? Why do you think it is located exactly where it is?

D: The Alcoa refinery, Point Henry

Location

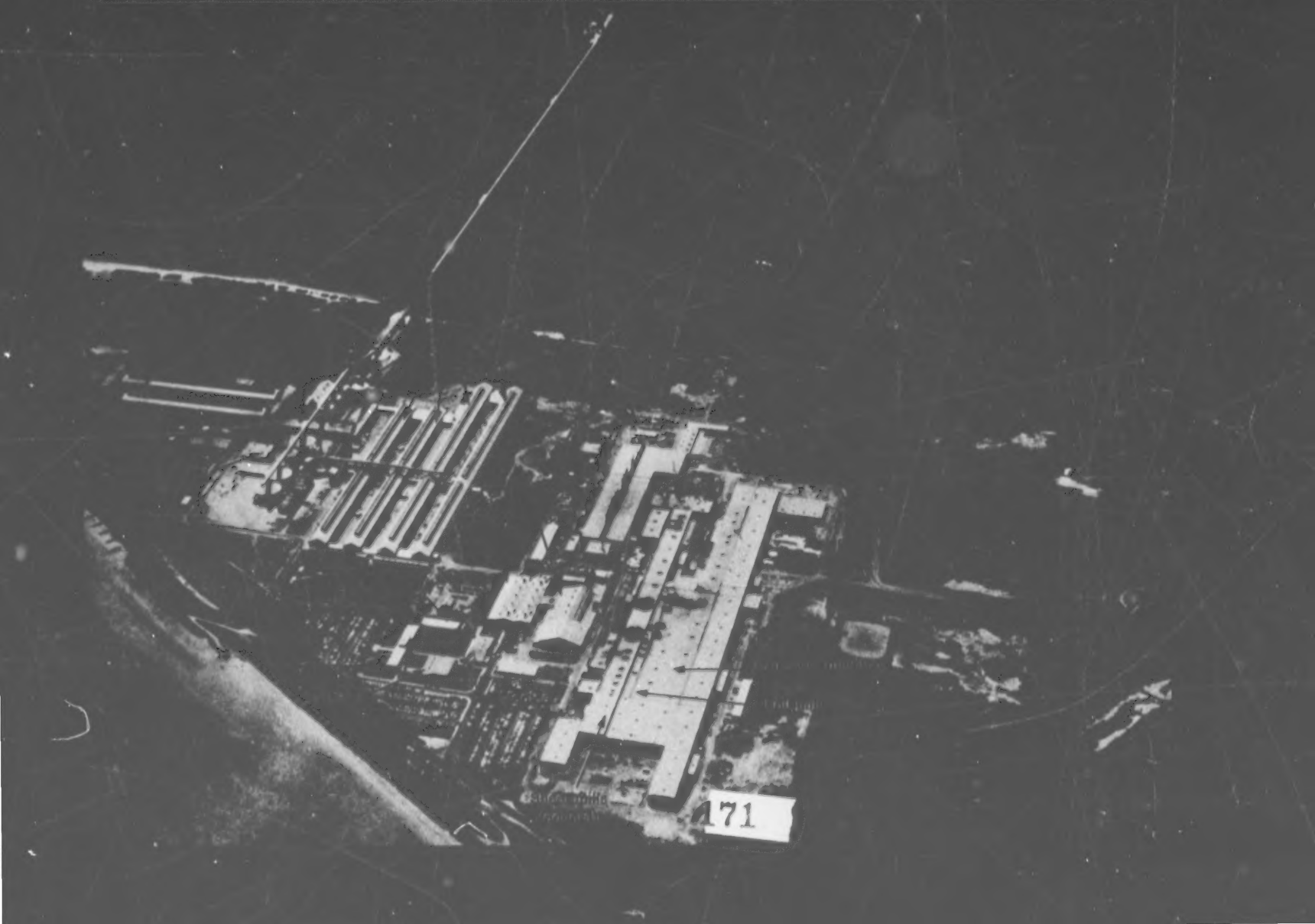
See figure 15.22 and figures 15.36 and 15.37.

The process

Aluminium is a relatively new metal, for the process necessary to separate the metal from the oxygen with which it is chemically combined in alumina was only discovered in 1886 when Charles Martin Hall (U.S.A.) and Paul Héroult (France) found that passing an electric current through a solution of cryolite and alumina produced the pure metal in cheap, commercial quantities.

Let Alcoa tell the story of the Point Henry refinery in their own words, in these extracts from one of the company's publications:

Figure 15.36: The Point Henry aluminium smelter of Alcoa of Australia



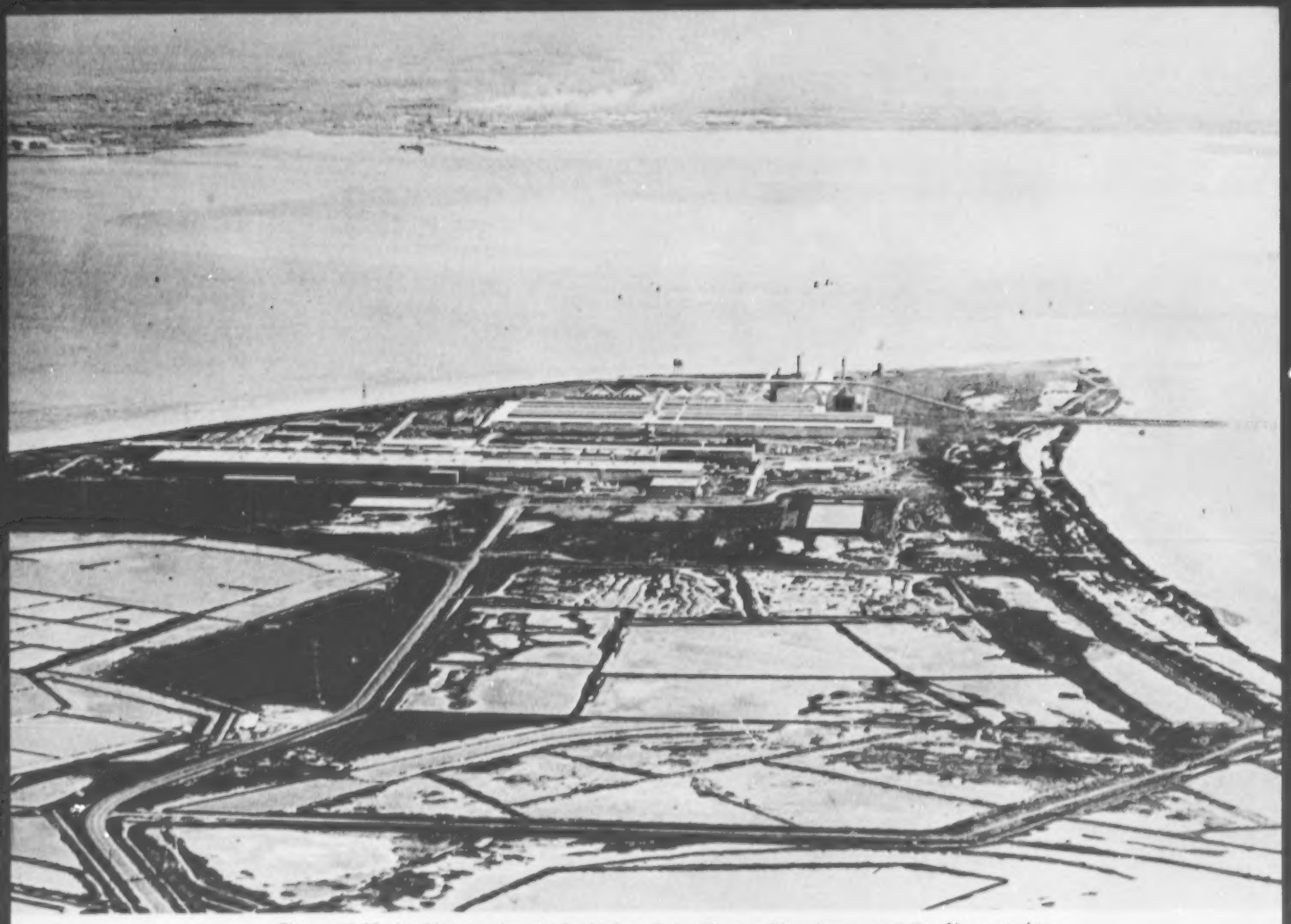


Figure 15.37: Looking north over Corio Bay–Point Henry with saltpans and the Alcoa works. Note Shell refinery at top centre

Smelting is carried out in rectangular steel 'pots' lined with carbon. Electricity is introduced into the cryolite-alumina bath of each pot through anodes—a set of carbon blocks suspended from overhead. The passage of electricity causes metallic aluminium to be deposited at the bottom of the pot (cathode) while the oxygen that was part of the alumina combines with the carbon anodes and is released as carbon dioxide gas.

Smelting is a continuous process. Periodically, molten aluminium is siphoned from the bottom of the pot and cast into ingots or charged into holding furnaces. As the alumina content in the cryolite is reduced, more alumina is added. Smelting takes place in rows of many cells, connected in series, called a potline.

The raw materials

The principal ore from which aluminium can be extracted economically is bauxite, a material that takes its name from Les Baux, France, where it was first discovered. Chemically, bauxite consists of hydrated aluminium oxide, together with oxides of iron, silicon, titanium and other elements and varying small percentages of clay and other silicates. Physically, it may be as hard as rock or as soft as mud. Its colour may be buff, pink, yellow, red, white or various combinations of these hues.

Before smelting, the impurities are removed from bauxite in an alumina refining process. Caustic soda is an important material in this operation. Commercially pure alumina (aluminium oxide) is the major raw material in the metal smelting process.

Alumina must be dissolved before metallic aluminium can be separated from the oxygen with which it is combined. The material used for this purpose is cryolite (sodium aluminium fluoride), which is found in mineral form in Greenland. Nowadays, the cryolite used in smelting is largely synthetic.

Another essential material in aluminium smelting is carbon, which is used to conduct electricity through the smelting furnaces. About 0·5 kilogram of carbon is consumed for each kilogram of metal produced.

The electrolytic process requires immense amounts of electricity at relatively low cost and with reliable continuity.

But why set up a refinery in Australia and why at Geelong?

Markets for aluminium

Australian and world demand for aluminium is rising steadily. So marked is the trend that the major producing countries in recent times have been installing new plant at a

brisk rate to give them the capacity to keep up with the market.

Australia's use of aluminium has increased dramatically in the past two decades. In 1950, total Australian consumption was 13 200 tonnes, representing an average per head of population of only 1·7 kilograms. Ten years later, at the beginning of the decade that ushered in Australian production of primary aluminium and its fabrication into finished shapes, the total had more than quadrupled to 54 000 tonnes (5·3 kg per head). By 1966, five years after the founding of Alcoa of Australia, it was up to 86 500 tonnes (7·5 kg per head).

Australia's annual aluminium consumption figure topped 100 000 tonnes for the first time in 1968, ending the year at 111 700 tonnes (9·3 kg per head).

The following year, the nation's per capita usage of 10·2 kilograms (a total of 124 900 tonnes) surpassed that of the United Kingdom. And while it was still well below that of the United States, where the figure is nearly 22·7 kilograms per head, it is expected to settle down eventually closer to the U.S. figure. Canada and West Germany are the only two other non-Communist countries with higher per capita consumption than Australia.

A number of developments are seen as responsible for the expanding Australian market. These include growth of poulation, the rising standard of living, the ready availability of locally produced aluminium, competition within the industry and the resulting spread of knowledge about the metal, its properties and uses. Export opportunities for Australia rise from its wealth of raw materials and the modern techniques now being applied to aluminium production.

How the Alcoa project developed

A number of favourable factors combined to make the Alcoa of Australia project a practical proposition. These were reliable commercial deposits of bauxite; a nearby site for an alumina plant, where bauxite ore is refined; a source of economical electricity for the smelting of aluminium; access to markets for aluminium ingot and fabricated products, and capital resources for the vast expenditure involved.

Bauxite deposits

In 1957, Western Mining Corporation began a prospecting programme to determine the extent of the Darling Ranges bauxite deposits. Within a year, the prospecting brought encouraging results, and Broken Hill South Limited and North Broken Hill Limited joined Western Mining to form Western Aluminium N.L. This group pursued the project and, by 1960, first hopes were confirmed.

Bauxite deposits were proven in an area about 320 kilometres long and 40 kilometres wide, beginning less than 50 kilometres from the settled West Australian seaboard. This was a most favourable geographical location, promising significant economies in transport.

The nature of the bauxite deposit was also impressive. It lay close to the surface with an average overburden of only 75 centimetres, its alumina content was satisfactory, and its chemical and physical properties were particularly suitable for the efficient refining of alumina. The ore was seen to be comparable with high-grade bauxites in other parts of the world.

Sites for refinery and smelter chosen

With the basic requirement satisfied, the Australian group pushed quickly ahead to develop an aluminium industry. Kwinana, 32 kilometres south of Perth, and handy to the ore deposits, was chosen as the site of an alumina refinery. A fuel source to provide the energy for low-cost electric power generation became available in the newly-developed brown coal deposits at Anglesea, Victoria. This source in turn was a governing factor in the selection of Point Henry, Victoria, as the site of an aluminium smelter. Point Henry is near the port city of Geelong, offering ready access to the large Melbourne market area and good facilities for shipping to other markets, both in Australia and abroad.

Alcoa of Australia has built its own generating station at Anglesea to supply the Point Henry works with the vast quantities of electric energy it consumes. The station uses about 1·2 million tonnes of brown coal a year from the Anglesea deposits. The State Electricity Commission now supplies supplementary power only.

Smelting aluminium at Point Henry

The smelter at Point Henry produces primary aluminium from West Australian alumina. It has a capacity of 90 000 tonnes of metal a year, and uses about 180 000 tonnes of alumina annually. Carbon blocks used in the smelting process are manufactured in an adjoining plant. Aluminium from the smelter is sold in ingot form or further fabricated at the Point Henry works.

Fabricating aluminium at Point Henry

The fabricating plants at Point Henry convert aluminium from the adjacent smelter into ingot and mill products. Ingots are cast in many forms and sizes. The main mill products are extruded shapes; extruded tube, rod and bar; and sheet, plate and foil. Ingots and mill products become the raw materials for many other industries. The fabricating facilities consist of four major units: the remelt and ingot casting plant, the extrusion plant, the rolling mills and the laboratory.

Alcoa's ingots are largely trucked to Melbourne for shipping interstate and overseas, because Geelong port cannot attract enough general cargo vessels for goods to be shipped regularly to markets, and there seems to be no change in sight in the near future.

Do the facts of the refinery's location match up with the reasons that are given for the location? Can you think of any other reasons for the refinery being located where it is? Look carefully at the photographs to help you answer this question.

These four studies of particular factories have provided detailed examples of how factories operate and how manufacturers decide to construct or set up factories. From the general study of Geelong you should have several ideas about the various factors that affect the distribution of

factories. To what extent do particular manufacturers appear to be concerned about these factors? Do manufacturers engaged in light industry and heavy industry think differently about the location of their factories?

But there is one other factor we haven't considered yet. When anything is manufactured there is some output that is waste. Think about each of the four factories you have studied. What waste is there from each factory? Are any of the factories doing anything about how their waste might affect other people? What should they do?

16

Manufacturing in Montreal

Montreal is the largest city in Canada, with a population of 2 743 205 (1971). From an Australian point of view, the inland location of this major urban centre is somewhat unusual (see figure 16.1). During the nineteenth century, however, dredging and canal works improved navigation of the St Lawrence both upstream and downstream of Montreal, which emerged as the chief St Lawrence port, surpassing Quebec. (Compare their locations in figure 16.1—why might Quebec at first have been more important?) Montreal received and transhipped cargoes from overseas ports and from the inland.

Figure 16.1: Location of Montreal

The opening of the St Lawrence Seaway in June 1959, from Lake Ontario in the west to Montreal in the east, meant that larger vessels could ascend the waterway beyond Montreal. How might this have affected the city's role as a port? Nevertheless, there has been no decline in Montreal's port function; the number of ships docking there has increased rather than decreased.

Apart from this port function, then, what other attractions does Montreal have that might explain its growth? Examine the material in figures 16.2, 16.3 and 16.6, derived from publications designed to attract industrialists to Montreal.

What attractions are these maps and diagrams trying to emphasise? Are the attractions really as good as the material suggests? As an industrialist thinking of locating a factory in Montreal, what other information would you want?

Figure 16.4 shows the power sources for Montreal. The city generally lacks the normal thermal power; what kind of power appears to be available? In the context of global energy problems, how should Montreal fare?

Figure 16.2: Over 10 000 000 people live within a radius of 500 kilometres from Montreal, 55 000 000 within a radius of 800 kilometres, and 75 000 000 within a radius of 1000 kilometres

Figure 16.3: Montreal—distance from major urban centres

Table 16.1: Major manufacturing industry groups, metropolitan Montreal, 1969

	Establishments	Employees	Shipments ($'000)
Foods and beverages	458	34 395	1 299 383
Transportation equipment	98	26 137	780 968
Clothing industries	1 332	49 363	706 169
Metal fabricating industries	645	26 199	638 725
Primary metal industries	30	5 340	496 723
Petroleum and coal products	14	2 528	476 864
Electrical products	133	18 974	446 830
Chemical products	244	13 367	394 095
Printing and publishing	681	15 312	266 330
Textile industries	288	10 957	233 364
Paper and allied industries	117	8 979	215 302
Miscellaneous industries	581	12 012	203 161
Furniture and fixtures	444	9 792	162 074
Tobacco products	8	4 338	159 796
Non-metallic mineral products	126	6 983	157 257
Knitting mills	159	9 784	147 016
Machinery industries	81	7 248	130 414
Leather industries	180	8 863	114 613
Rubber industries	21	2 158	49 099
Wood industries	86	2 022	32 619
TOTAL	5 726	274 751	7 110 802

Source: Quebec Bureau of Statistics

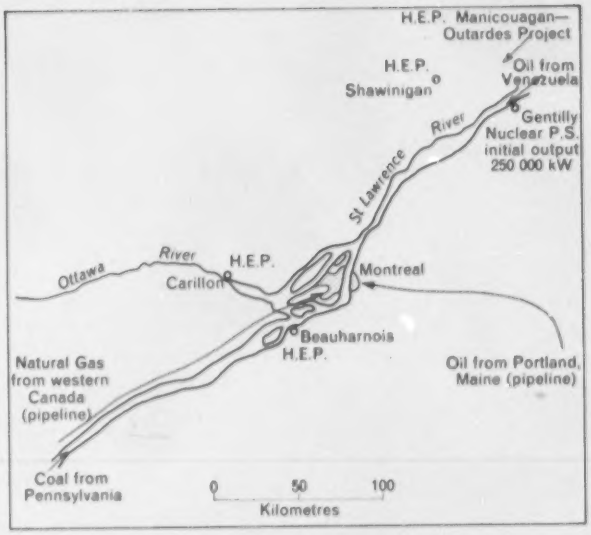


Figure 16.4: Montreal's power sources

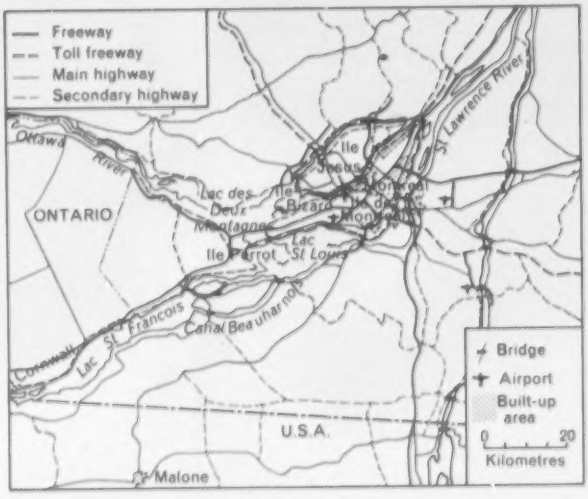
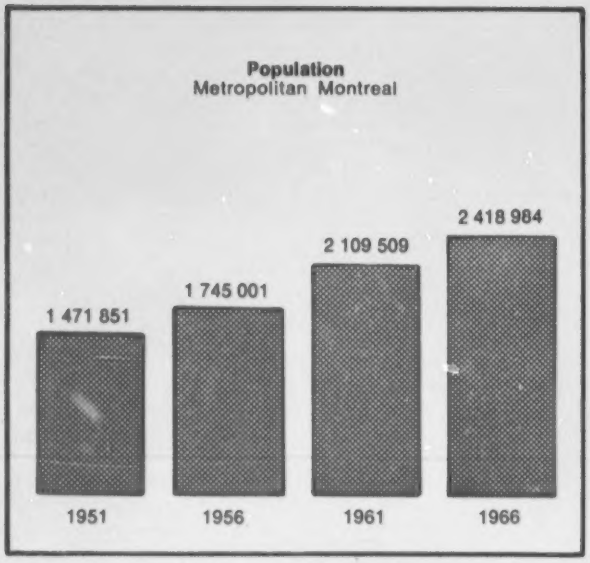
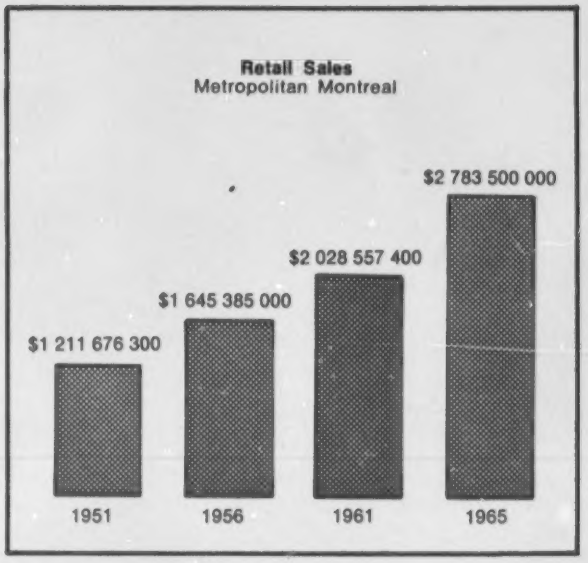


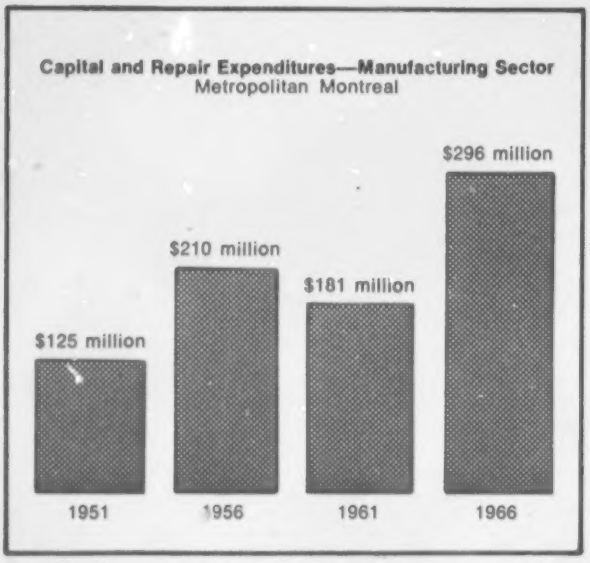
Figure 16.5

As you can see from figure 16.5, Montreal is largely located on an island in the St Lawrence. What disadvantages would such a location have for manufacturers? Would it have any advantages? If you look at figure 11.30 on page 105, you can see that Montreal's urban area has increased in recent decades. In which direction has the settlement spread? Why do you think this direction was favoured more than others?

What manufacturing has developed in Montreal? This kind of question is often answered by examining statistics. But statistics are difficult to use. To be counted, different things have to be put into categories, and the number of categories you decide to use can affect the answers you get. For example, compare tables 16.1 and 16.2. (Note that the dates are different.) Which table gives greater







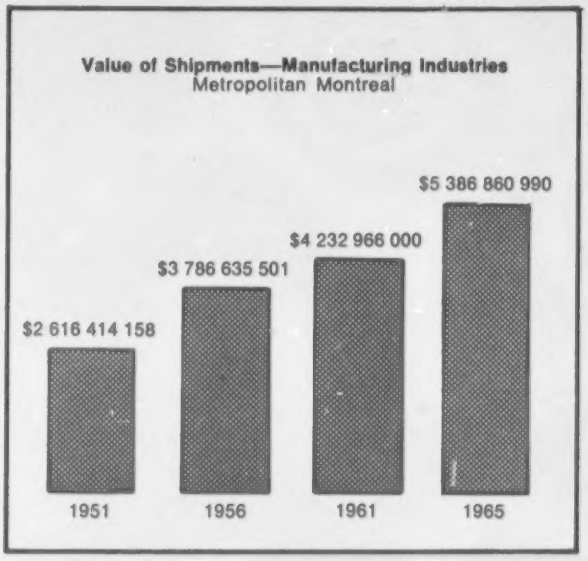


Figure 16.6

detail? What differences do you find in trying to work out an answer to our question? Which appear to be the most important manufacturing industries in Montreal?

There is another way of using statistics to find out the important types of manufacturing in a city. For example, if a large country had 20 per cent of its manufacturing value in food industries and a city in that country had the same percentage in food industries, then that would not be very unusual. On the other hand, if the country had 5 per cent of its manufacturing value in car manufacturing and the city had 12 per cent of its manufacturing value in car manufacturing, then that would be more than twice what you would expect. Examine table 16.3. On this basis, which industries appear to be most important in Montreal?

Examine table 15.7 on page 140 and find, in Geelong, examples of those industries that are important in Montreal. What reasons did they give for locating in Geelong? Could these factors be the same for manufacturing firms in Montreal? What other reasons could you suggest for these manufacturing industries being more important in

Table 16.2: Principal statistics by leading industries, metropolitan Montreal, 1964

	Establishments	Employees	Shipments ($'000)
Petroleum refining	6	2 378	385 263
Women's clothing factories	395	19 156	239 853
Aircraft and parts manufacturers	19	12 955	189 346
Slaughtering and meat packing plants	31	4 065	153 675
Men's clothing factories	228	11 509	151 126
Miscellaneous food manufacturers	59	2 804	142 845
Tobacco products manufacturers	10	4 815	134 456
Metal stamping, pressing and coating industry	98	5 796	109 257
Miscellaneous machinery and equipment manufacturers	47	6 242	101 359
Communications equipment manufacturers	26	8 676	96 923
Wire and wire products manufacturers	44	3 979	91 116
Manufacturers of pharmaceuticals and medicines	54	4 705	90 086
Sugar refineries	3	1 072	79 080
Manufacturers of electric wire and cable	4	2 227	72 443
Printing and publishing	27	5 253	71 986
Breweries	4	2 831	69 050
Flour mills	4	808	67 336
Process cheese manufacturers	3	858	66 789
Other knitting mills	95	4 308	66 280
Children's clothing industry	112	6 186	64 680
Copper and alloy rolling, casting and extruding	8	1 127	64 169
Bakeries	159	4 555	62 529
Shoe factories	60	5 869	56 655
Printing and bookbinding	305	4 808	56 492
Manufacturers of household radio and television receivers	10	2 756	56 200
Pasteurising plants	19	2 039	53 940
Manufacturers of plastics and synthetic resins	5	1 024	51 947
Miscellaneous textiles industry	76	3 182	50 365
Softdrink manufacturers	25	2 599	50 154
Corrugated box manufacturers	10	1 993	48 253
Fabricated structural metal industry	11	3 165	45 998
Household furniture industry	262	3 758	45 739
Ornamental and architectural metal industry	106	2 865	44 560
Paint and varnish manufacturers	31	1 496	43 566
Biscuit manufacturers	11	2 879	41 416
Lithographing	83	2 602	40 303
Fur goods industry	247	1 672	38 703
Shipbuilding and repair	4	2 741	38 323
Ready-mix concrete manufacturers	7	1 425	36 049
Miscellaneous metal fabricating industries	47	2 590	35 358
Feed manufacturers	7	572	34 462
Other furniture industries	70	2 635	32 758
Manufacturers of miscellaneous electrical products	31	1 911	32 729
Instrument and related products manufacturers	20	2 139	32 424
Publishing only	95	1 697	31 774
Confectionery manufacturers	33	1 884	31 434
Hosiery mills	61	2 652	29 918
Folding boxes and set-up boxes manufacturers	24	1 941	29 367
Manufacturers of major appliances (electric and non-electric)	4	1 230	28 372
Paper bag manufacturers	21	1 233	28 101
Cotton yarn and cloth mills	6	1 990	28 081
Fruit and vegetable canners and preservers	39	1 254	27 775
Other rubber industries	18	1 440	27 176
Glass manufacturers	3	2 194	26 779
Hardware, tool and cutlery manufacturers	58	1 626	26 012
Other chemical industries	62	1 325	25 966
Manufacturers of toilet preparations	19	1 280	25 596
Miscellaneous paper converters	44	1 381	25 372
Linoleum and coated fabrics industry	6	1 301	24 402
Heating equipment manufacturers	17	1 697	24 267
Manufacturers of industrial chemicals	11	545	23 005
Synthetic textile mills	5	797	22 126
Asphalt roofing manufacturers	5	784	21 986
Plastics fabricators	56	1 275	21 770
Miscellaneous leather products manufacturers	80	2 351	20 340

For distilleries, iron and steel mills, smelting and refining, railroad rolling stock and cement manufacturers, figures cannot be given according to the Statistics Law.

Source: Quebec Bureau of Statistics

Table 16.3: Fifteen major manufacturing industry groups, Canada and Montreal, 1969

Industry	Percentage of shipment value	
	Canada	Montreal
Foods and beverages	18·1	18·2
Transportation equipment	13·7	11·0
Clothing	2·8	9·9
Metal fabricating	6·9	9·0
Primary metal	7·8	7·0
Petroleum and coal products	3·9	6·7
Electrical products	6·0	6·3
Chemical products	5·9	5·7
Printing and publishing	3·2	3·7
Textiles	3·7	3·3
Paper and allied industries	8·3	3·0
Furniture and fixtures	1·5	2·3
Tobacco products	1·3	2·2
Non-metallic mineral products	2·7	2·2
Knitting mills	0·8	2·1

Montreal than we would expect? Figures 16.2 to 16.6 may provide some answers, and the role of Montreal as a port may also give you some clues.

In which parts of Montreal is manufacturing concentrated? Examine figures 16.7 and 16.8. The difficulties involved in interpreting these maps are that:

- figure 16.7 only indicates principal areas;
- figure 16.8 shows factories distributed according to municipalities, which in many cases extend over wide areas (see figure 16.9);
- some factories are larger than others and produce more.

Look at table 16.4 and figure 16.9. Table 16.4 gives the data on which figure 16.8 was mapped, and details of numbers of employees and value of shipments. Using figure 16.9 and this data, you could map average size of factory (on an employment basis) and average shipment value per factory for each municipality. This would give you a clearer picture of the distribution of factories in Montreal.

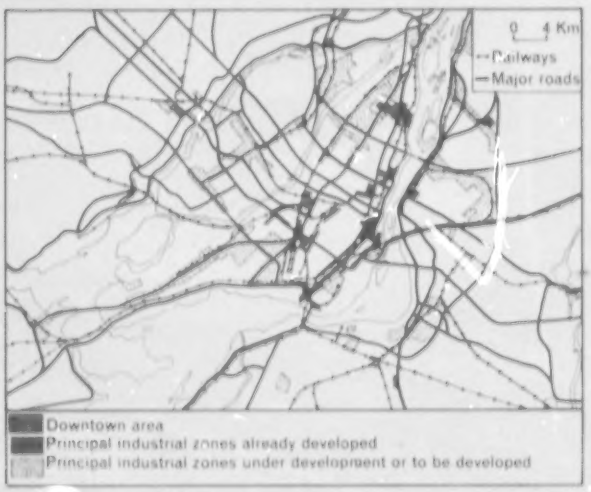


Figure 16.7: Industrial zones of metropolitan Montreal, 1971

Figure 16.9: Municipalities of Montreal (see table 16.4 for key)

Figure 16.8: Distribution of factories in Montreal, 1969 (based on municipalities)

Figure 16.10: Montreal—population distribution, 1970

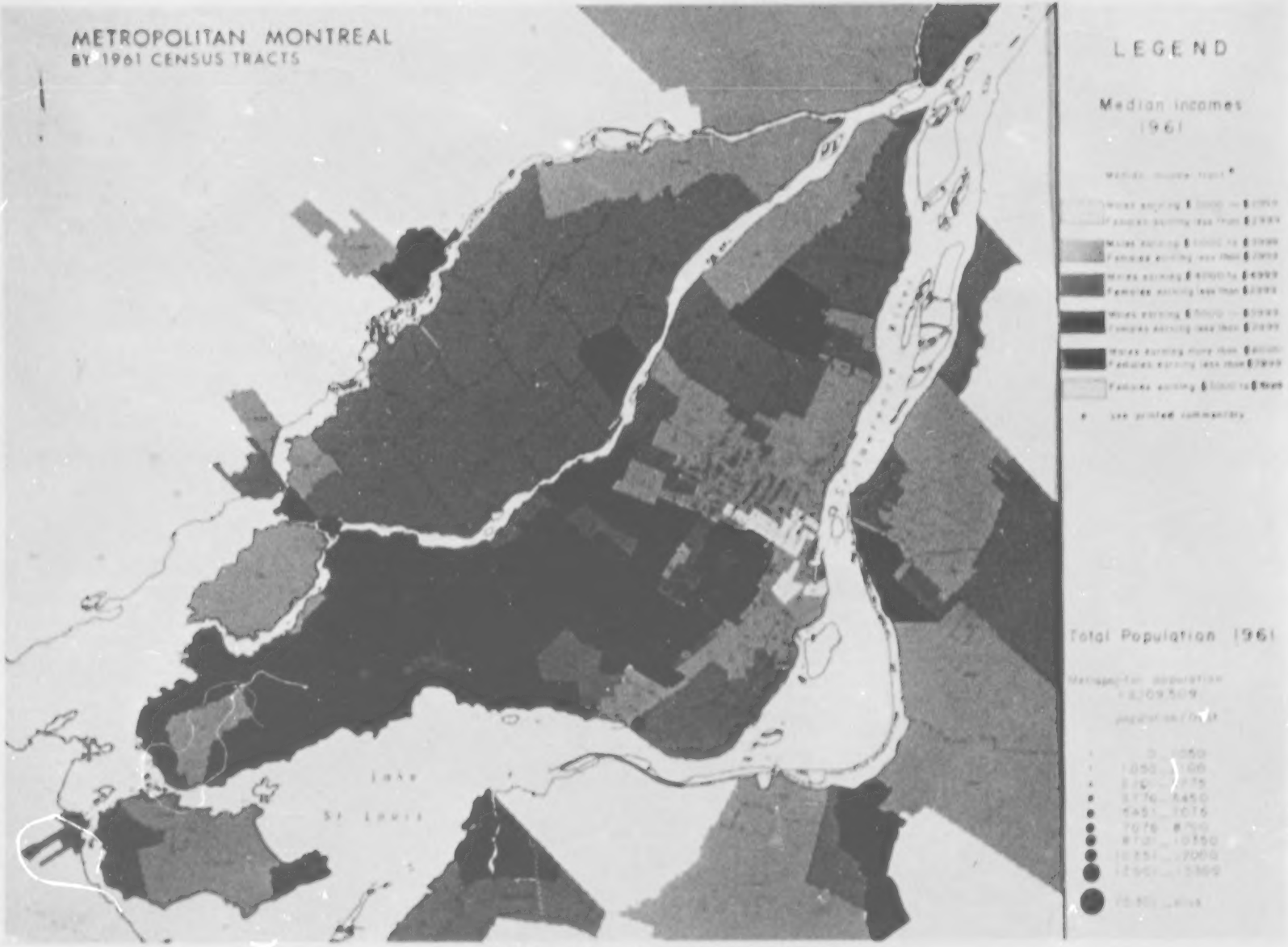


Figure 16.11: Montreal—median incomes, 1961

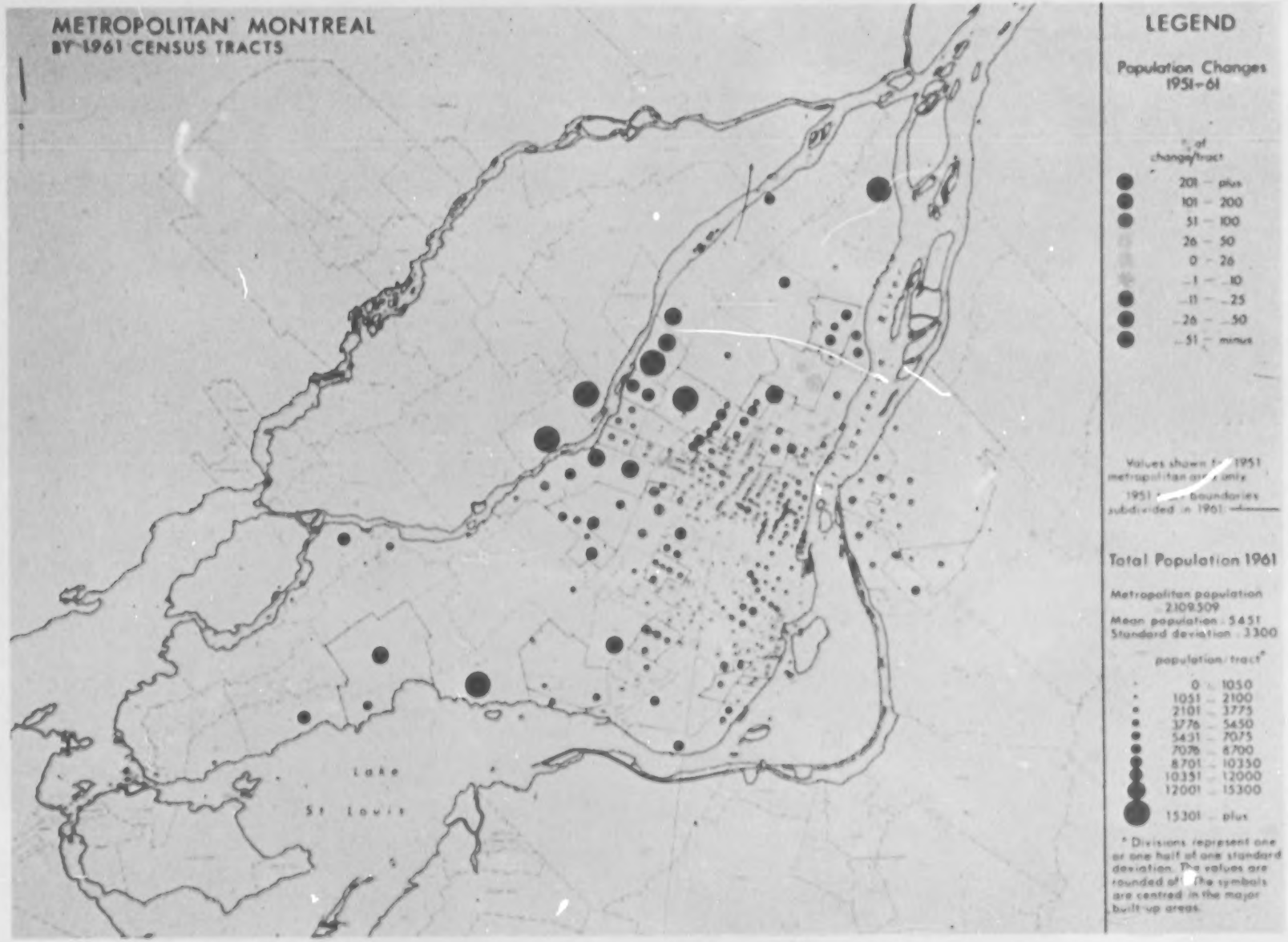


Figure 16.12: Montreal—population changes, 1951–61

Table 16.4: Distribution by municipalities of manufacturing industries, metropolitan Montreal, 1969

	Establishments	Employees	Shipments ($'000)
Montreal Island			
1. Montreal	3 856	164 223	2 681 107
2. St-Laurent	134	18 313	303 531
3. Lachine	87	13 603	240 994
4. Mont-Royal	60	7 684	208 524
5. La Salle	62	6 723	241 548
6. Montréal-Est	38	6 656	683 860
7. St-Michel	177	3 731	71 995
8. Outremont	81	2 740	48 957
9. Montréal-Nord	163	2 688	39 556
10. Pointe-Claire	30	2 398	55 522
11. Westmount	37	2 034	41 480
12. Verdun	71	2 018	20 253
13. St-Pierre	32	1 364	22 066
14. Pointe-aux-Trembles	23	1 294	67 733
15. Anjou	24	1 248	57 033
16. Côte St-Luc 17. Hampstead	10	1 001	25 933
18. Dorval	22	684	11 148
19. St-Léonard	23	483	5 856
20. Montréal-Ouest	11	160	1 986
21. Senneville 22. Ste-Anne de Bellevue 23. Baie D'urfe 24. Beaconsfield 25. Kirkland 26. Dollard des Ormeaux 27. Roxboro 28. Ste-Geneviève 29. Pierrefonds 30. St-Raphael de l'Ile Bizard	16	514	5 636
Jesus Island			
31. Laval	123	2 206	34 604
South Shore			
32. Jacques-Cartier	41	5 126	92 681
33. Longueuil	43	2 938	28 434
34. St-Lambert	24	1 457	18 391
35. Candiac	8	1 009	21 239
36. Laprairie	23	640	7 401
37. St-Hubert	19	195	2 087
38. Greenfield Park 39. Lemoyne 40. Préville	20	450	8 023
41. Boucherville 42. St-Bruno	9	116	1 671
43. Brossard 44. Notre-Dame	7	119	2 398
45. Delson 46. St-Constant 47. Ste-Catherine 48. Châteauguay 49. Châteauguay-Centre 50. Châteauguay-Heights 51. Léry	14	271	14 673
	7	22	568
North Shore			
52. Ste-Thérèse 53. Rosemere	40	2 304	34 702
54. St-Eustache 55. Deux-Montagnes	24	556	6 499
56. Dorion	14	320	3 108
57. Ile Perrot 58. Notre-Dame de l'Ile Perrot 59. Pincourt 60. Pointe du Moulin 61. Terrasse Vaudreuil	11	119	2 311

Source: Quebec Bureau of Statistics

From your analysis, where are factories concentrated in Montreal? Refer to the transport information in figure 16.7 and the population data in figures 16.10, 16.11 and 16.12; what evidence can you find to explain the pattern of manufacturing?

Figure 16.13 shows concentrations of particular manufacturing types in Montreal. These all tend to be on the outskirts of the major city limits. What reasons can you give for the particular concentrations? What types of industries would you expect to find in the more densely populated areas of Montreal?

Figures 16.14 and 16.15 are advertisements for three 'industrial parks' in Montreal, which are trying to attract manufacturers to locate in their area. What are the advantages of each, according to the advertisements? What are their disadvantages, from what you have seen of Montreal? In each case, would you advise a large firm to locate there?

Figure 16.13: Concentrations of particular manufacturing types in Montreal

UNIQUE? YES SIR!

LONGUEUIL

ON THE OUTSKIRTS OF MONTREAL
CANADA'S METROPOLIS . . . A

$6 BILLION MARKET

WITH ALL FACILITIES REQUIRED BY ALL TYPES OF INDUSTRIES

For convincing proof, ask for our illustrated colour brochure, complete with all facts and figures.

Write to:
The Director of Industrial Development
City Hall
100 St- Charles Street, Wes
LONGUEUIL, P.Q.

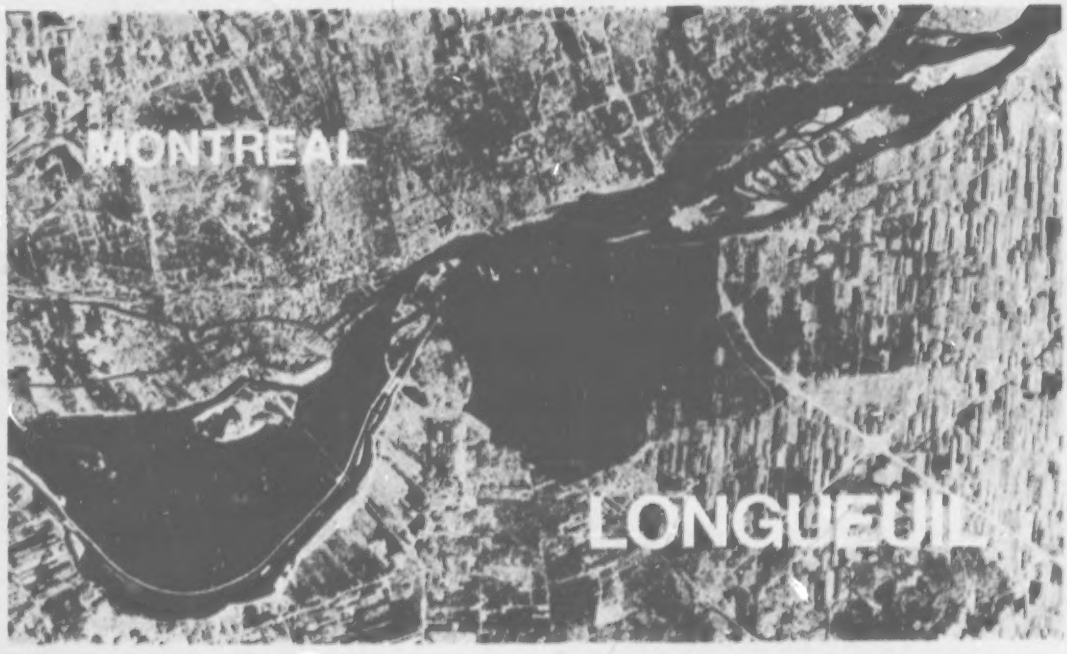
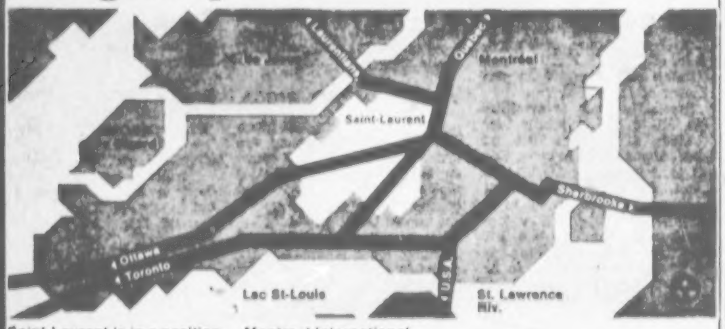


Figure 16.14: An advertisement for Longueuil as a site for industrial location

Saint-Laurent Quebec's second industrial city and the hub of tomorrow's megalopolis



Saint-Laurent is in a position to offer you every service you require.

201 million square feet reserved for industrial use

Right in the heart of Montreal Island and its labor pool.

At the crossroads of all main communication arteries:

Trans-Canada Highway
Metropolitan Boulevard
Laurentian Autoroute
Decarie Expressway

Montreal International Airport

The hump yards and PiggyBack terminus of the CNR and CPR

Public transportation

More than 490 industries already established

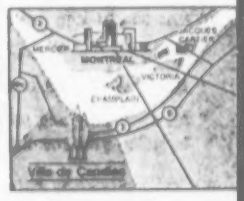
For detailed information, contact:
Mr. Charles Robitaille
Industrial Commissioner
777, Laurentian Boulevard
Saint-Laurent 379, Que., Canada
Tel: (514) 744-6411, local 237

Saint-Laurent
QUEBEC'S
SECOND
INDUSTRIAL
CITY

Join 21 leading industries in a prime Montreal location on the South Shore

- 15 minutes from downtown Montreal.
- 30 minutes from U.S. border.
- Intersected by 3 expressways.
- Full utility, rail and municipal services.
- Industrial financing available.

LA VILLE DE
Candiac
INDUSTRIAL PARK



Information: Mr. J. P. Robitaille, Candiac Development Corporation,
1420 Sherbrooke St. W., Montreal 109, P.Q.
Phone: (514) 845-0475

9 Montcalm Boulevard, Candiac, P.Q.
Phone: (514) 659-5435

Figure 16.15: Advertisements for Saint-Laurent and Candiac as sites for industrial location

17

Developing an iron and steel plant in Malaysia

In studies 15 and 16 you examined general patterns of manufacturing in two major urban centres of countries with a high level of industrial development; in particular you considered the factors that determine factory location in such societies. But do these factors also apply in countries with little manufacturing development? What difficulties do such countries face in establishing industries? What do you think is meant by 'import replacement'? Why would the Malaysian government want to encourage 'import replacement' industries?

The production of iron and steel is usually held to be an important requirement for industrial development. Refer to table 17.1. What do these statistics tell you of Malaysia's level of industrial development in 1967? Why might the Malaysian government have wished to change this situation?

Table 17.1: Trade figures, West Malaysia, 1967

Classification	Imports (US $ thousand)	Exports (US $ thousand)
Food, beverages and tobacco	226 003	60 373
Crude materials, inedible	55 596	513 500
Mineral fuels and lubricants	67 536	18 336
Animal and vegetable oils	3 763	44 713
Chemicals	75 563	15 766
Manufactured goods	171 770	276 106
Machinery and transport equipment	191 760	20 240
Others	71 116	23 893
Total	863 107	972 927

In an attempt to remedy the obvious imbalances, the Malaysian government has been endeavouring to promote 'import replacement' manufacturing; it has especially encouraged manufacture of food, paint, rubber, wood and fabricated metal products and motor assembly, by a 'pioneer industry' policy. This policy granted tax-exemption 'holidays' to companies establishing themselves in these fields, allowed import of necessary materials duty-free, and provided tariff protection for such industries.

The 'pioneer industry' policy has been successful in bringing about the establishment of factories manufacturing the products listed above. But iron and steel production was not included in the list of manufacturing types to be encouraged. Why not? Go through the list again. How important is an iron and steel industry to these manufacturing types? Do *you* think iron and steel production is important for a country's industrial development? The Malaysian government did.

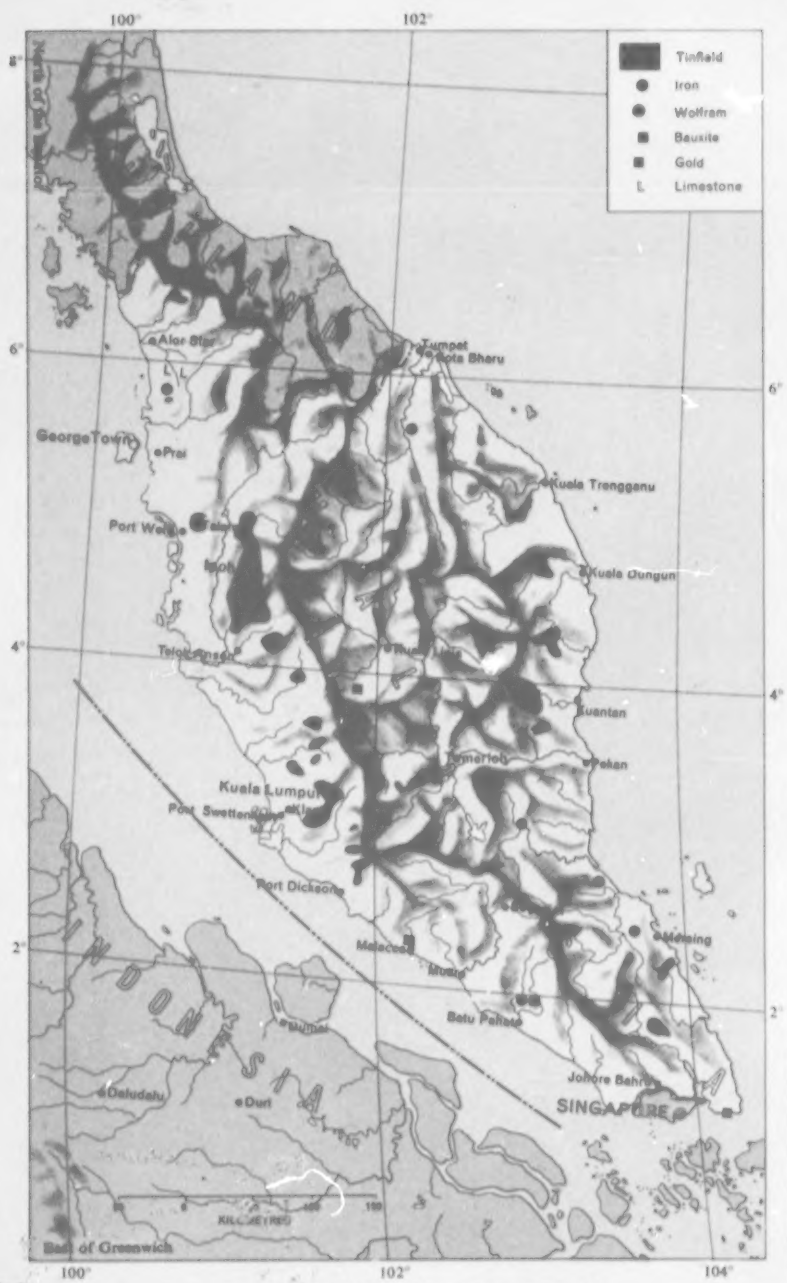
But could the country provide the three necessary raw materials? Malaysia has iron ore and limestone deposits, but no coking coal (see figure 17.1). In place of coking coal, it was decided that charcoal could be used, manufactured from timber collected from the rubber plantations throughout Malaysia (figure 17.2). As replanting is a continual process on the plantations, a reliable timber supply was available. Thus an added advantage of iron and steel production was the economic benefit the rubber industry would derive from utilisation of its timber for charcoal manufacture.

In 1961 the Malayawata Steel Berhad company was established, with 51 per cent Malaysian capital and a 49 per cent Japanese interest held by a consortium of Japanese companies headed by Yawata Iron and Steel Company Ltd, who provided the expertise necessary to set up an iron and steel plant. The Malaysian government, which has a small financial interest, granted the company 'pioneer' status in 1962 and provided the incentives mentioned earlier.

The site and raw materials

Where was the plant to be established? Consider the raw materials needed, all possible transport requirements, and the labour force that would be necessary. Refer to figures 17.1–17.4. On the basis of the information in these maps, where would you have located the plant?

The site actually selected was on the Sungei Prai (Prai River) close to the town of Prai and the port of Butterworth (figures 17.5 and 17.6). What are the advantages of this location? Why do you think the plant was located on the western side of the Malay Peninsula rather than the eastern side?


Tinfield
Iron
Wolfram
Bauxite
Gold
Limestone
Alor Star
Tumpat
Kota Bharu
George Town
Prai
Kuala Trengganu
Port Weld
Ipoh
Kuala Dungun
Telok Anson
Kuala Lipis
Kuantan
Temerloh
Pekan
Kuala Lumpur
Port Swettenham
Port Dickson
Malacca
Muar
Mersing
Batu Pahat
Johore Bahru
SINGAPORE
Dumai
Sibolga
Gunung Sitoli
Meulaboh
Banda Aceh
Lhokseumawe
Sabang
Pulau Weh
Pulau Simeulue
Pulau Nias
Pulau Siberut
Padang
Bengkulu
Palembang
Pangkalpinang
Pulau Bangka
Pulau Belitung
Tanjungpandan
Pontianak
Singkawang
Sambas
Pulau Natuna Besar
Ranai
Tarempa
Pulau Tambelan
Pulau Anambas
Pulau Laut
Pulau Sebuku
Pulau Sebatik
Tarakan
Nunukan
Tanjungselor
Tanjungredeb
Sangkulirang
Samarinda
Balikpapan
Pulau Balabalagan
Pulau Tarakan
Pulau Bunyu
Pulau Derawan
Pulau Maratua
Pulau Kalimantan
Pulau Sebuku
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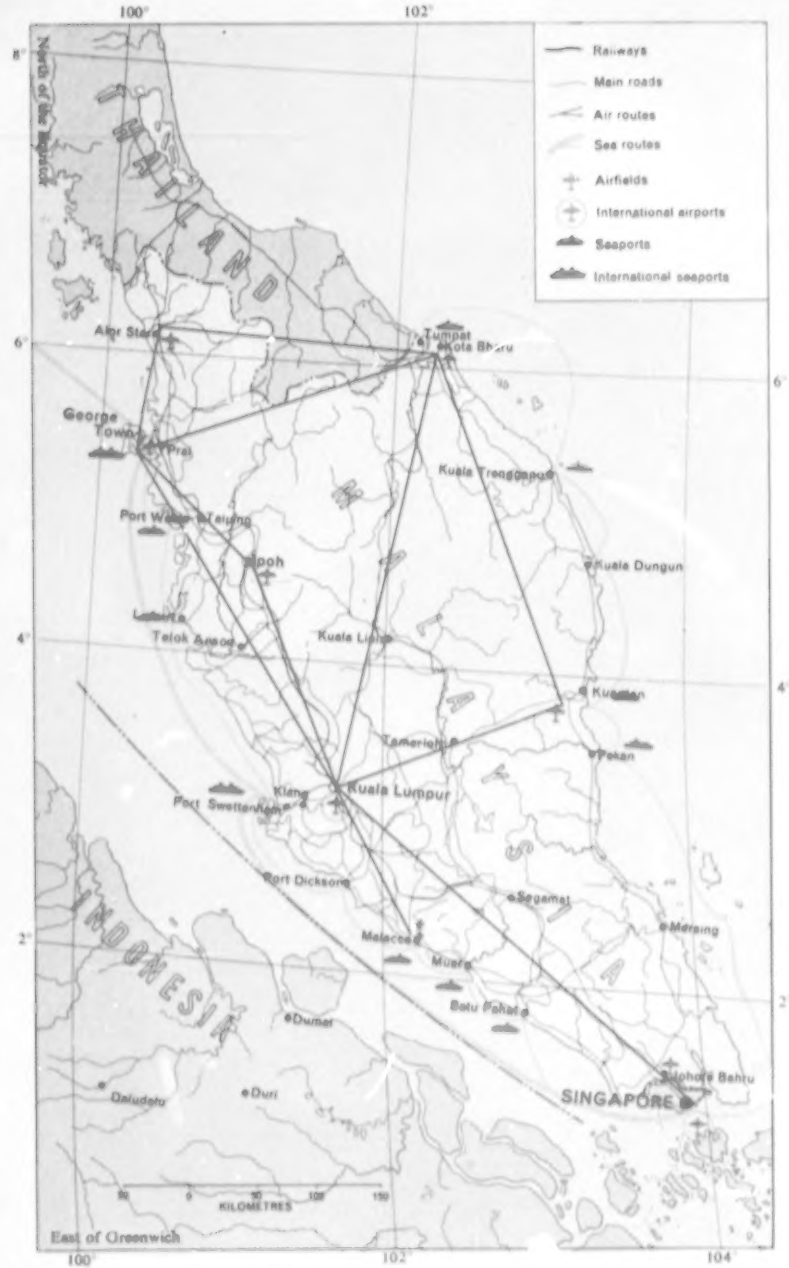


Figure 17.3: West Malaysia—transport ilities

Figure 17.4: West Malaysia—population distribution

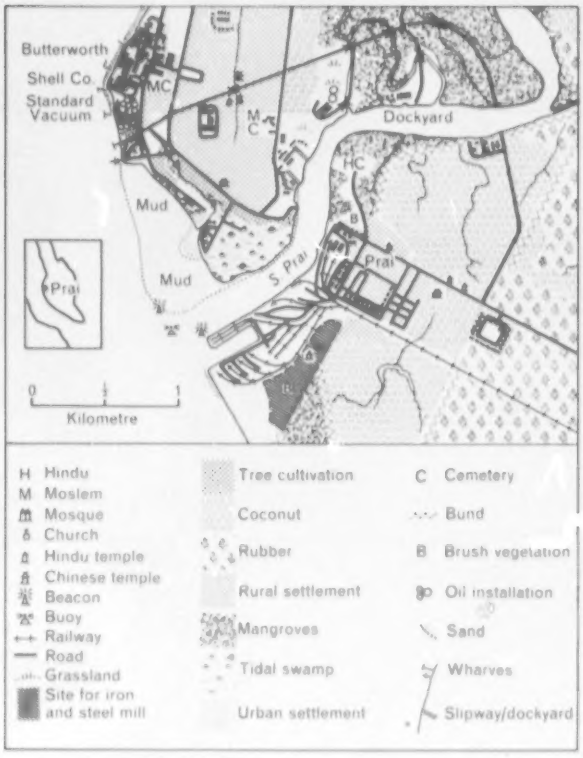


Figure 17.5: Site of the Malayawata iron and steel plant

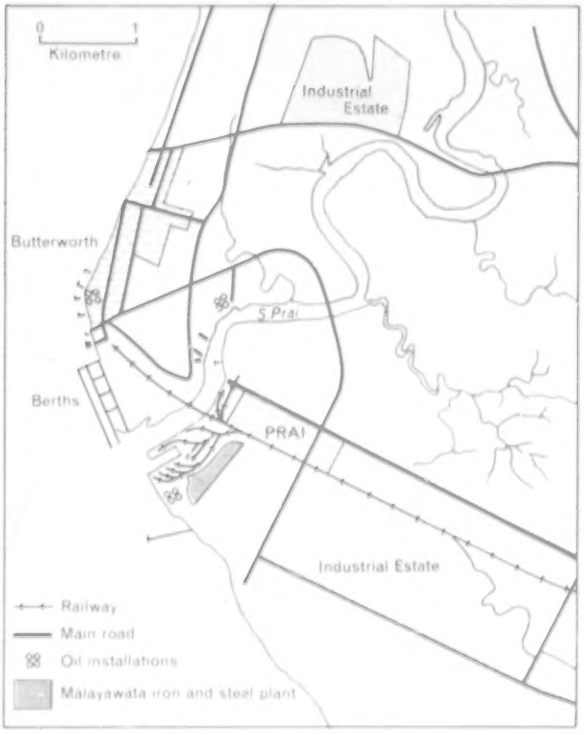


Figure 17.6: Development of the area surrounding the Malayawata plant

Part of the 18-hectare site was originally mangrove swampland, which has been drained and filled. (What effect might this have had on local fishing?) The Prai area is being developed as an industrial district (figure 17.6) and there are several other large industrial ventures, including the Malaysian Sugar Refinery.

Using the information in table 17.2, make a map from figures 17.1 and 17.3 to show the movements of raw materials to the steelworks.

Table 17.2: Raw materials for Malayawata steelworks

Raw material	Location	Type of transport
Iron ore	Perak, Kedah, Johore	mostly rail
Limestone	Kedah, Perak	road
Charcoal	Kedah, Perak, Prov. Wellesley	road
Manganese, silicon	India and Japan	ship
Sea water*	locally	—

*Daily requirement for cooling purposes: 22 700 000–25 000 000 litres

A subsidiary company, Malayawata Charcoal Sendirian Berhad, was formed to provide charcoal from seven kilns set up throughout the area close to the plant (figure 17.7). Contractors collect timber from rubber planters and deliver it to the kilns.

Figure 17.7: Location of charcoal kilns supplying the Malayawata plant

Establishment of the plant

The plant's history proceeded thus:

- April 1966—construction of phase I commenced:
  Seven charcoal kiln centres
  Sintering plant

No. 1 blast furnace
Steel-making plant
Rolling plant
No. 1 oxygen plant
Auxiliary service facilities—maintenance, power, water, transportation, analysis and testing

- August 1967—completion of phase I and commencement of production
- September 1969—construction of phase IIA commenced:
  No. 2 blast furnace
  Expansion of steel-making plant
  Modifications to rolling mill
  Wire rod mill
  No. 2 oxygen plant
  Additional auxiliary service mills
- December 1970—completion of phase IIA
- Phase IIB when completed will include:
  Electric arc furnace
  Continuous casting plant
  Hot-coil processing line: slitting line, cold forming line, slitted bar line
  Further auxiliary service facilities.

The capacity of each blast furnace is 170 tonnes per day, but production is only about two-thirds of this figure.

Compare figures 17.8 and 17.9 showing the layout of the Malayawata plant; draw a labelled sketch of the buildings in figure 17.8 and, by reference to figure 17.10, a flow chart of the production process, add arrows and labels to your sketch to show the movement of materials through the plant.

Identify the various types of finished product from figure 17.10. None are exported; the Malayawata plant's total output is utilised within Malaysia, and supplies most of the country's requirements of steel products and cast pig iron. The major market is the building industry.

Examine table 17.3 in relation to table 17.1. Is there any evidence that, by 1969, the plant and the government's policy had influenced Malaysia's trade situation?

Table 17.3: Trade figures, West Malaysia, 1969

Classification	Imports (US $ thousand)	Exports (US $ thousand)
Food, beverages and tobacco	213 774	74 268
Crude materials, inedible	96 475	764 551
Mineral fuels and lubricants	67 934	17 624
Animal and vegetable oils	5 276	53 590
Chemicals	79 671	18 989
Manufactured goods	178 295	352 121
Machinery and transport equipment	210 017	21 945
Others	64 036	28 289
Total	915 478	1 331 377

The steelworks has now begun to make a profit, and in 1972 its 'pioneer' status was extended for another two years. As well, tariff protection has been granted for a wide range of products.

Problems

1. Lack of skilled personnel

Although sufficient labour was available from nearby towns, the company had difficulty in obtaining adequately trained workers—most of the local men lacked industrial experience. As a result, skilled labour had to be brought from Japan, and some local key personnel were sent to Japan for training. An unskilled labourer receives M$5 per day while a more skilled labourer receives M$10–11 per day. However, there is a tendency for the steelworks' skilled labour to be offered higher salaries as leading workers and foremen in other new industrial enterprises, such as the developing electronics industry on nearby Penang Island.

2. Pollution

Along the coast near Prai there are numerous fishing villages, and neighbouring Penang Island, a free port with beautiful beaches, is considered West Malaysia's major resort area. Iron and steel plants produce large amounts of smoke, and use huge volumes of water in their cooling processes, heating it and normally discharging it into rivers or sea. What effect would these two outputs have on the local area? What would you do to control any deleterious effects?

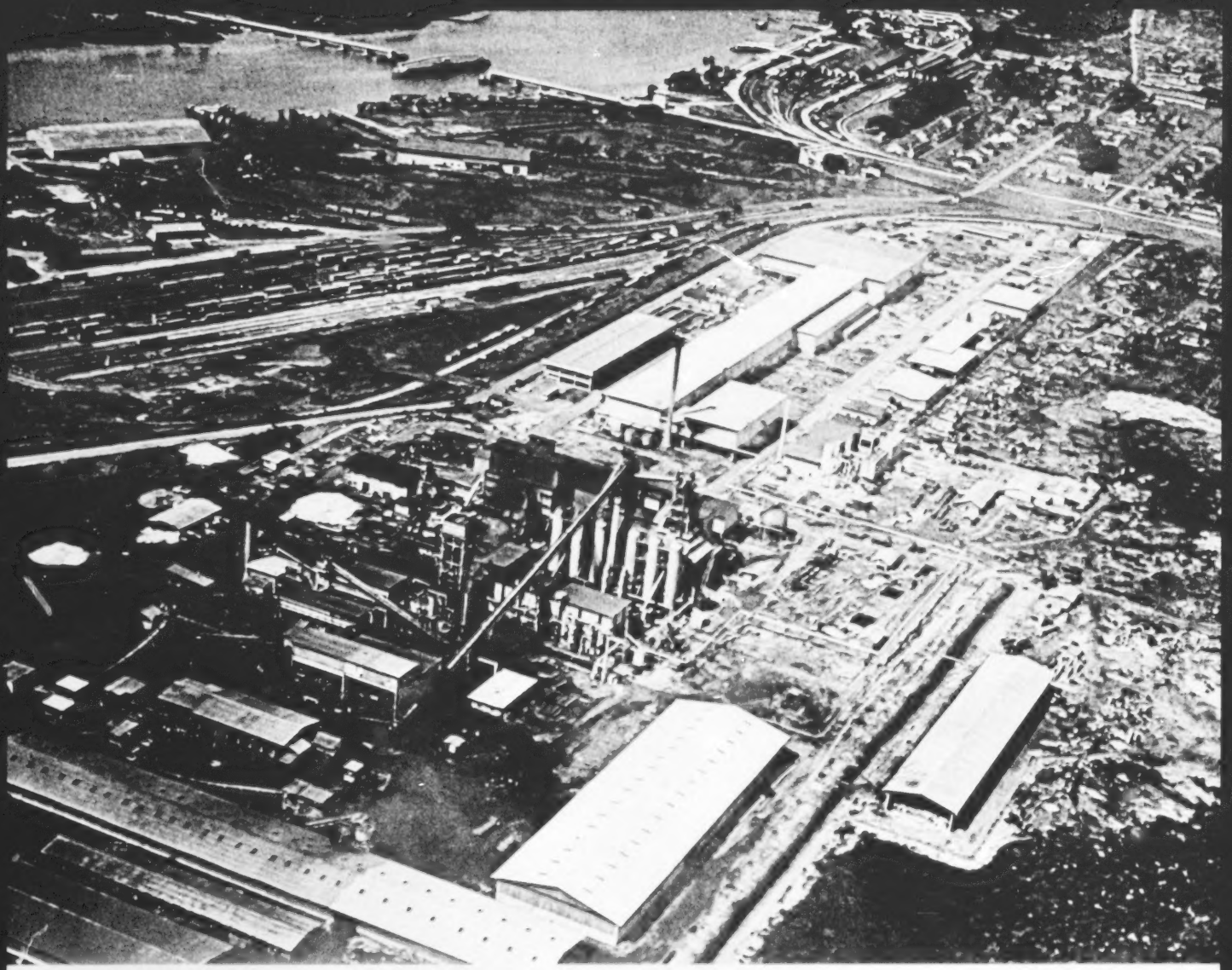
3. Foreign dependence

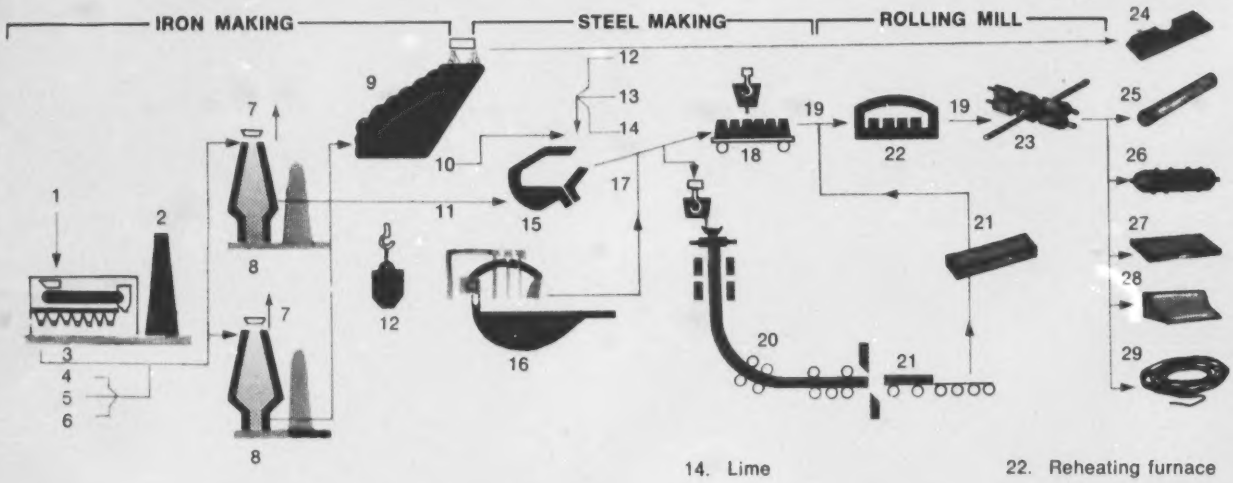
As the plant was built with Japanese guidance and planning, repair and replacement of equipment is to a large extent dependent on access to Japanese suppliers and technical advisers.

4. Nationalist policy

Government policy in Malaysia is consciously moving towards the creation of a Malay national character; one aspect of this is an emphasis on Malaysian ownership of the country's resources, employment of local labour, and development providing maximum local benefit. The ownership of 49 per cent of the Malayawata Steel Berhad by profit-seeking Japanese, and the dependence on the Japanese for technical guidance and servicing of the plant, have caused some conflict within the company.

Are there other problems arising from the development of modern manufacturing industries in countries like Malaysia? The urge to develop 'import replacement' industries results from their 'need' to import Western-style food and machinery. Do they really need to? Will these new industries, with all their advantages and disadvantages, give the people of these countries a better, happier life?





1. Fine iron ore
2. Sintering plant
3. Sintered iron ore
4. Iron ore
5. Charcoal
6. Limestone
7. Gas
8. Blast furnace
9. Casting machine
10. Oxygen
11. Molten metal
12. Scrap
13. Scale
14. Lime
15. Converter
16. Electric arc furnace
17. Molten steel
18. Moulding
19. Ingot
20. Continuous casting plant
21. Billet
22. Reheating furnace
23. Rolling mill
24. Pig iron
25. Round bar
26. Deformed bar
27. Flat bar
28. Angle bar
29. Wire rod

Figure 17.10: How iron and steel are made at the Malayawata plant

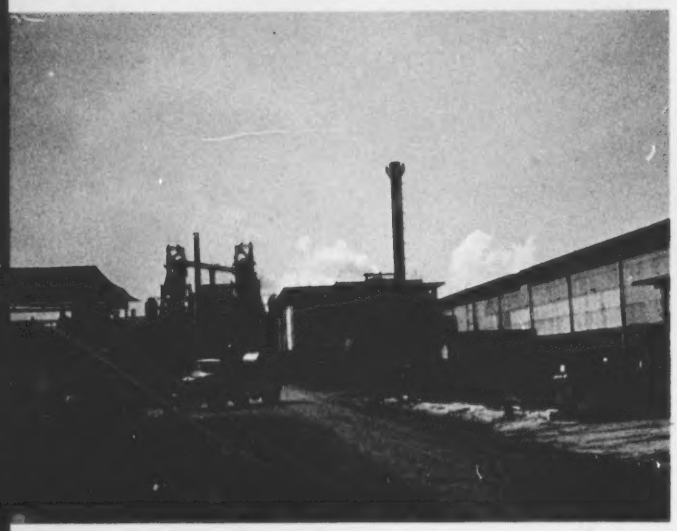


Figure 17.11: Blast furnace at the Malayawata plant, 1973

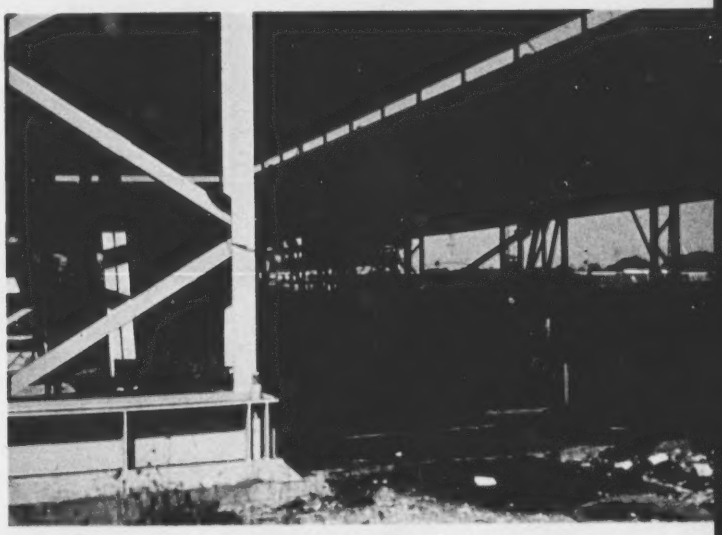


Figure 17.12: One of the Malayawata plant's outputs—wire rod (see figure 17.10)

18

Fruit canning in the Goulburn Valley

In study 4 you read about a farm producing apricots, peaches and pears in the Goulburn Valley of Victoria. About 85 per cent of the Goulburn Valley canning fruit crop is processed by three large co-operative canneries: Shepparton Preserving Company (S.P.C.) at Shepparton, Kyabram Preserving Company at Kyabram, and Ardmona Fruit Products Company at Mooroopna. The remaining 15 per cent is processed in Melbourne (see figure 18.1). What are the advantages and disadvantages of locating a cannery in an area like the Goulburn Valley? Do you think such a factory would be built there now? Why?

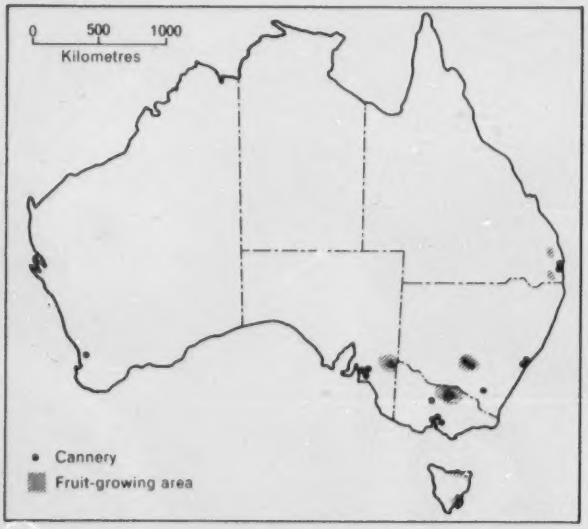


Figure 18.1: Canneries and main fruit-growing areas in Australia

How does the S.P.C. factory operate?

The farmer (in study 4, Mr Spivey) takes each truckload of fruit to an inspection area. Here, one bin is selected from the load and an 18 kilogram sample of fruit is taken for inspection and weighing (figure 18.2). The percentage of reject or unsatisfactory fruit removed from the sample by the inspector is used in calculating the rejection percentage of the total load. Payment to the grower is made accordingly.

Figure 18.2: Inspection and testing of fruit samples at the cannery laboratory

Once the fruit has passed inspection, the peaches and apricots are taken directly to the processing machines, while the pears go to the large cool-storage sheds where they are progressively ripened for processing.

Processing at the cannery takes place from late December to the end of April. Although the cannery is mostly mechanised, there is an upsurge in its labour requirements at this time, mainly for inspection of fruit and filling of cans, which is all done by women (figure 18.3). Most of the women who work in the cannery during the picking season are local residents, but the numbers also include wives of the fruit pickers. The permanent labour force of 290 is thereby increased to 1020 at this time of year. What would the order of fruit processing be? (Refer to figure 4.29 on page 28, and compare it with figure 18.4.)

Examine figures 18.5 and 18.6. Which of the activities that follow the processing of the fruit are depicted here? What means of transport are used to move the packaged cans away from the factory?

Figure 18.3: Apricot halves are closely inspected along continuous moving belts before being put into cans. What hygiene precautions are the employees required to observe? Do you notice anything unusual about the clothing being worn at this time of year? What would explain this?

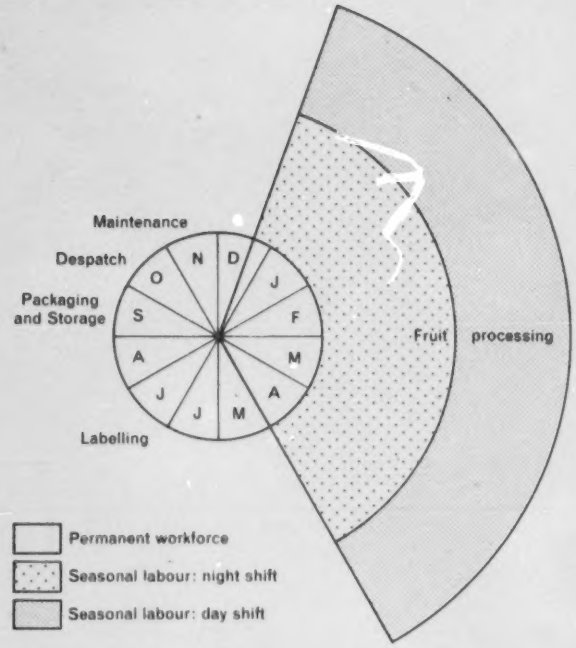


Figure 18.4: Annual work cycle and labour requirements at the S.P.C. cannery

Figure 18.5

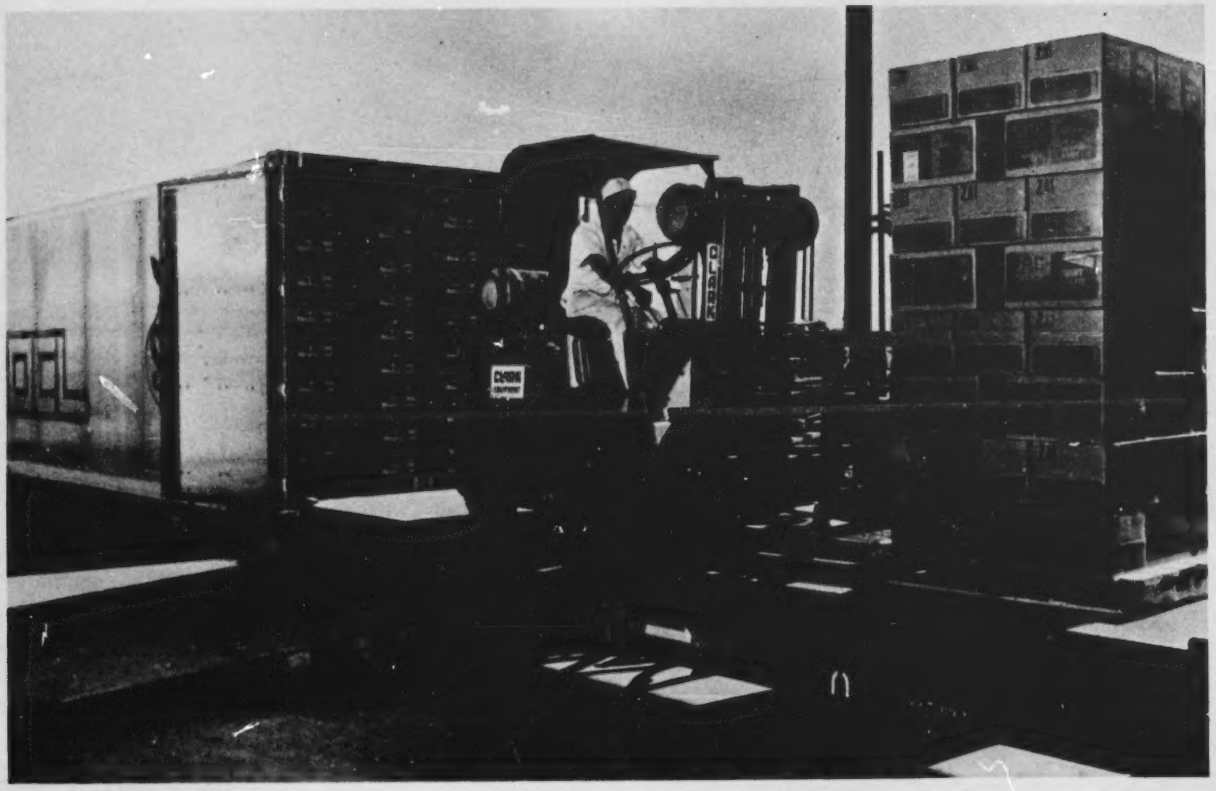


Figure 18.6

The 1968 production season was a record one for the Shepparton Preserving Company, with a total of 57 000 tonnes of fruit processed (figure 18.7). Can you suggest any reason for the different amounts of the various fruit types?

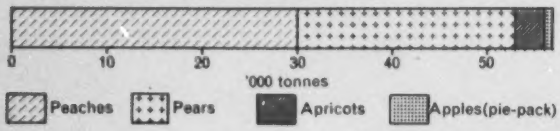


Figure 18.7: Canned fruit production at the S.P.C. cannery, 1968

The three Goulburn Valley canneries together produce over 100 000 tonnes of canned apricots, peaches and pears annually. This amounts to about 60 per cent of Australia's total production. In the 1966 season, the tonnage of Goulburn Valley fruit processed by *all* Victorian canneries reached the record figure of 120 000 tonnes out of an Australian total of 170 000 tonnes. The Goulburn Valley thus contributes 70 per cent of the total Australian pack of canned deciduous fruit.

The other main areas in Australia where deciduous fruit is grown for canning are the Murrumbidgee Irrigation Area of New South Wales, and the irrigation settlements along the Murray River in South Australia. (Locate these areas in figure 18.1.)

Table 18.1 shows the cannery production of deciduous fruits in Australia. What percentage of the total pack is contributed by each variety? Is this breakdown similar to that for processing at the S.P.C. cannery? (Calculate from figure 18.7.)

Table 18.1: Australian canned deciduous fruit pack (basic cartons*), 1968

Peaches	Pears	Apricots	Mixed fruit†	Total
5 134 000	3 206 000	723 000	1 902 000	10 965 000

*Basic carton: each carton holds a quantity of 24 x No. 2½ size cans or equivalent
†Includes canned 'two-fruits', fruit cocktail, fruit salad (other than tropical fruit salad)

Source: Australian Canned Fruits Board

Table 18.2: Exports of Australian canned deciduous fruits, 1968

Country	Basic cartons
United Kingdom	4 835 000
Europe	2 300 000
Canada	921 000
North and South America	214 000
Asia	124 000
Africa	95 000
Pacific Islands	46 000
Other	40 000
Total	8 575 000

Source: Australian Canned Fruits Board

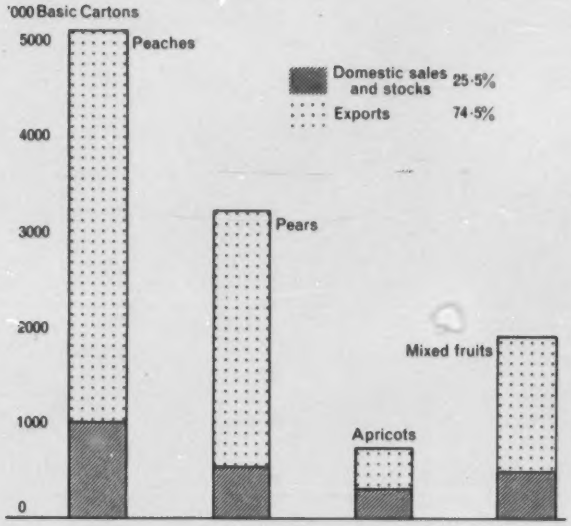


Figure 18.8: Distribution of the Australian canned deciduous fruit pack, 1968

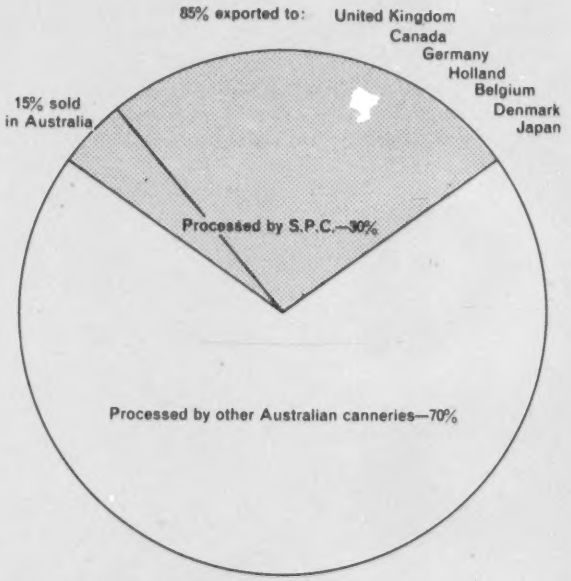
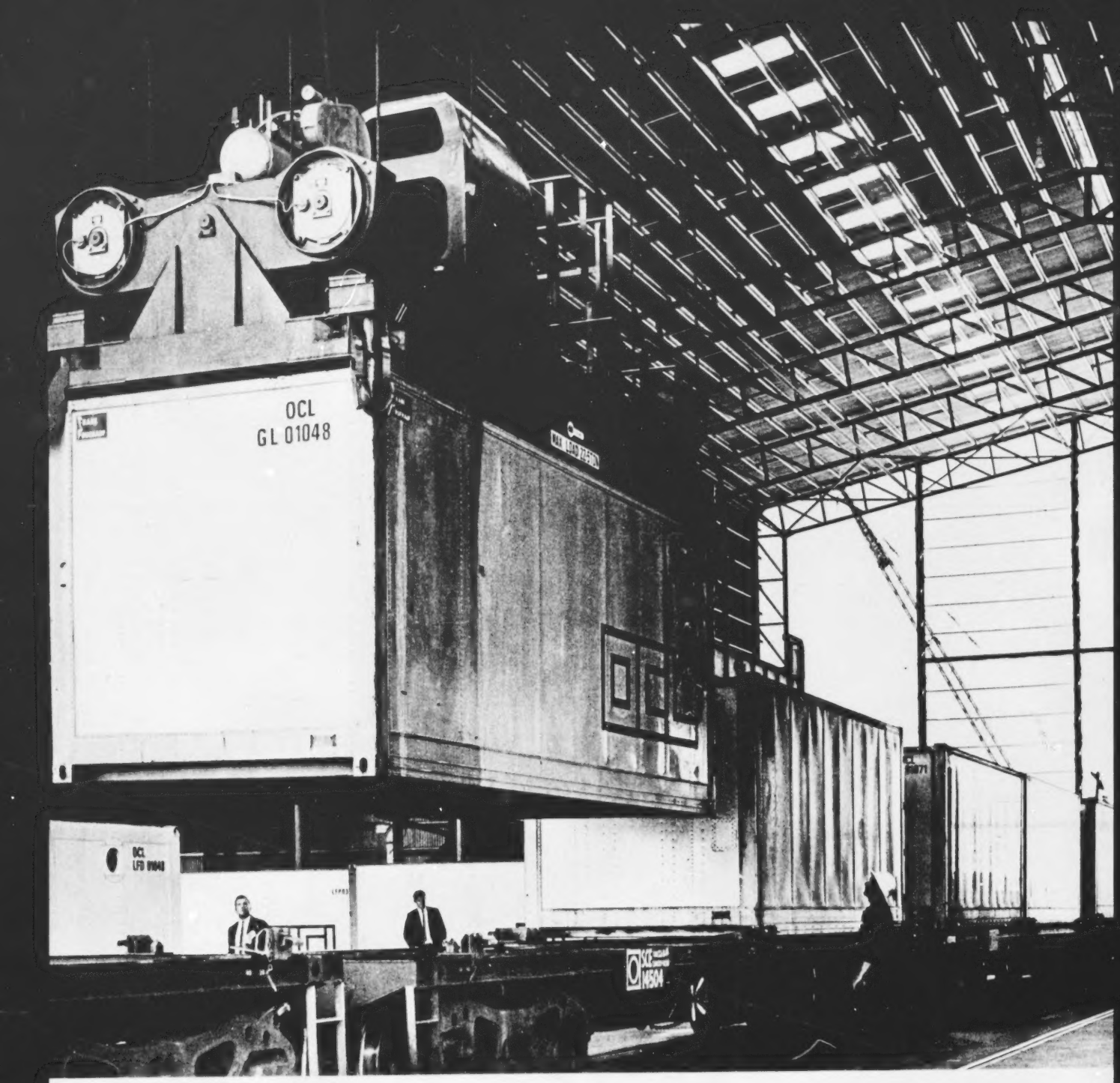


Figure 18.9: Processing (as a percentage of the Australian total) and destination of canned deciduous fruit pack, S.P.C. cannery, 1969

Examine figures 18.8 and 18.9, and table 18.2. On the basis of this data, draw a map of the world with flow lines indicating the proportions of the fruit exported going to each country. Are there any indications that these proportions may change in the future as a result of economic and political developments overseas?

As you can see in figure 18.9, S.P.C. produces about 30 per cent of Australia's total annual canned deciduous fruit pack, over 85 per cent of which is exported to overseas markets. Most exports are



Figures 18.10 and 18.11: Containers arriving at the Melbourne terminal by rail and road transport for loading on to container ships bound for the United Kingdom

now containerised. Each aluminium container, which holds a 20-tonne load of canned fruit, is transported to the shipping terminal in Melbourne by special flat-topped railway wagons and road transports (figures 18.6, 18.10 and 18.11). The main advantages of containerisation are ease and speed of handling, and prevention of damage to cartons in transit.

Figure 18.12 shows you the cannery and adjacent parts of Shepparton. The S.P.C. cannery covers a total area of 20 hectares and is the largest in the southern hemisphere. In addition to processing facilities, it also has its own can-making plant, which operates all year to produce about 100 million cans annually.

Locate the cannery in the topographic map extract, figure 4.4, on page 19, and examine figures 18.12 and 18.13. Study the factory layout in relation to the photograph and the map.

Make a field sketch of the aerial photograph and

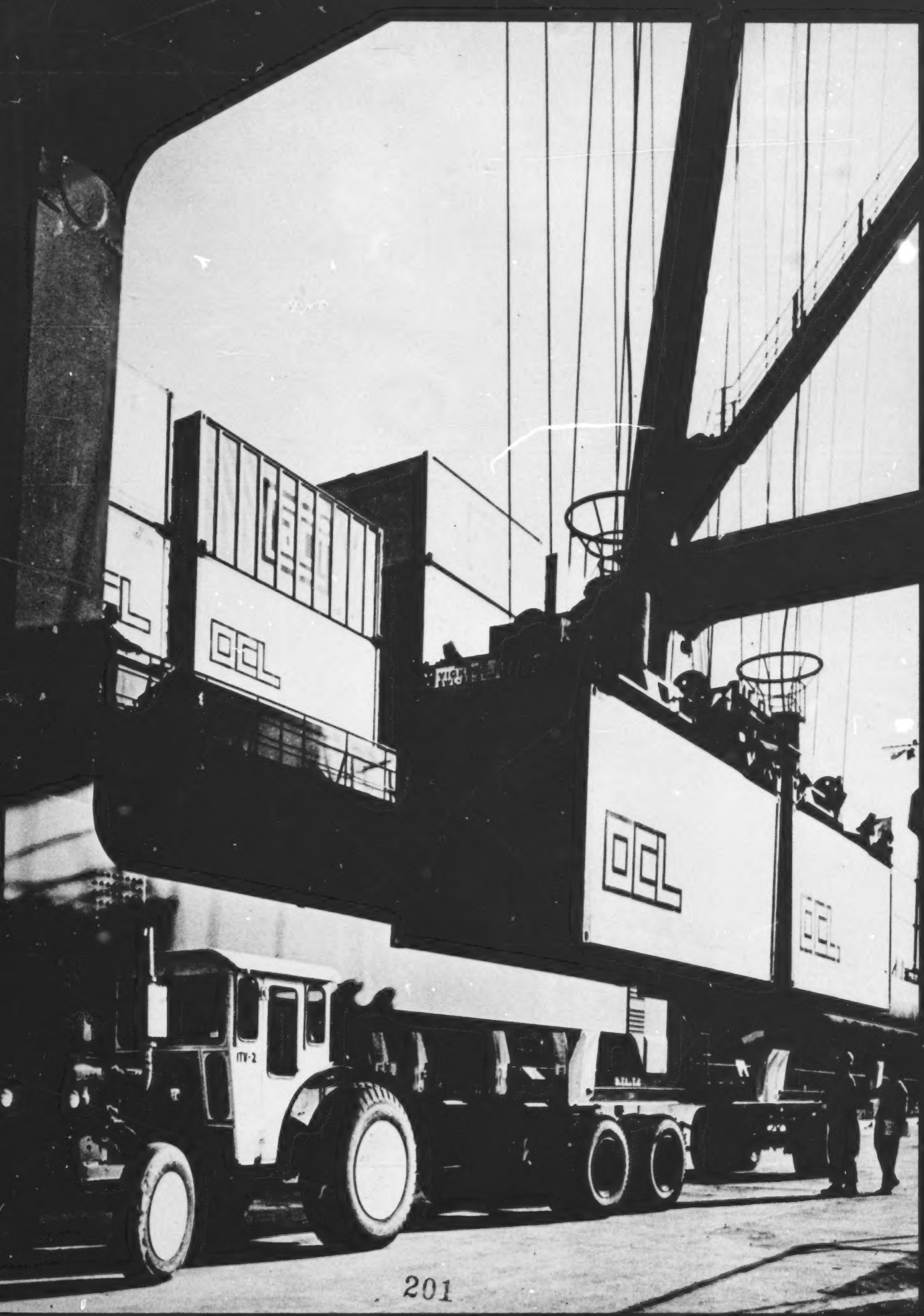

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Figure 18.12: Oblique aerial view of the S.P.C. cannery and adjacent parts of Shepparton

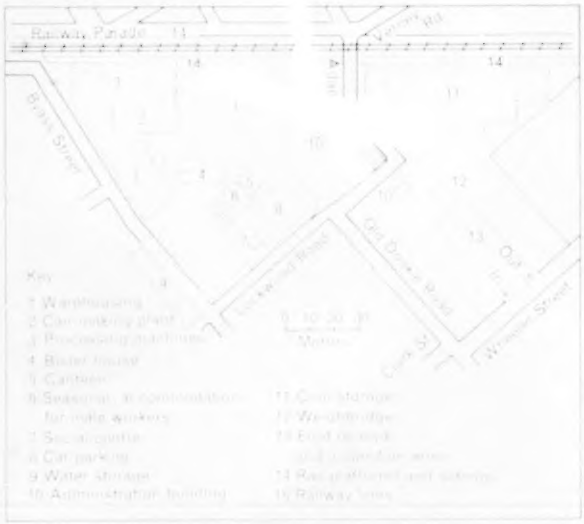


Figure 18.13: Layout of the S.P.C. cannery

label the different buildings with a number to correspond with the plan; put a north pointer on your sketch.

At the beginning of this study you were asked to suggest why a fruit cannery would be located in the Goulburn Valley. Your answer probably talked about the *general* location in the Goulburn Valley. But in figures 4.4, 18.12 and 18.13 you can see the *specific* location of the S.P.C. cannery in the city of Shepparton. From the photograph and the maps, why do you think the cannery is at that specific location?

The Shepparton City Council provided incentives for the cannery to be built. What incentives could a council offer, and why would a municipal council encourage manufacturing development?

19

Where would you build a factory?

In previous studies you have been examining manufacturing development in various contexts. Now you are asked to decide where you, as a locational expert, would build an iron and steel plant (about which you know something from study 17) or a furniture factory—you can choose whichever you prefer.

First, read the 'Context' details, which give you your brief.

CONTEXT

Iron and steel plant

You have been appointed by your company's board of directors to find a location for an iron and steel plant in the country of Corbland, because the government of this land has offered inducements of reduced taxation rates and financial assistance in setting up the plant.

These inducements were offered by the Corbland government when the announcement that a new iron and steel plant was to be established somewhere in this country was first made public. Your company's directors are assessing the potential of Corbland, and you have been instructed to select the best possible site for the plant that will be established if they decide to locate the new plant in this country.

After due consideration, Corbland is very highly rated by the board of directors, and as time is scarce its members wish your location decision for the Corbland plant to be final and definite.

Where in Corbland would you locate, and why?

Where, if applicable, in a particular Corbland city would you locate, and why?

Furniture firm

You represent a board of directors that has been elected by the firm's shareholders. Your current major problem is to find a suitable location for your firm. Your selection of locations has been narrowed down to somewhere in Corbland.

Remember that the majority of your shareholders are anxious for you to earn maximum profits so that they may receive maximum dividends. Therefore you must select a location that is as close as possible to optimal (best), according to *your* criteria, as your shareholders have the power to vote you out of office if your decision does not result in an adequate financial return.

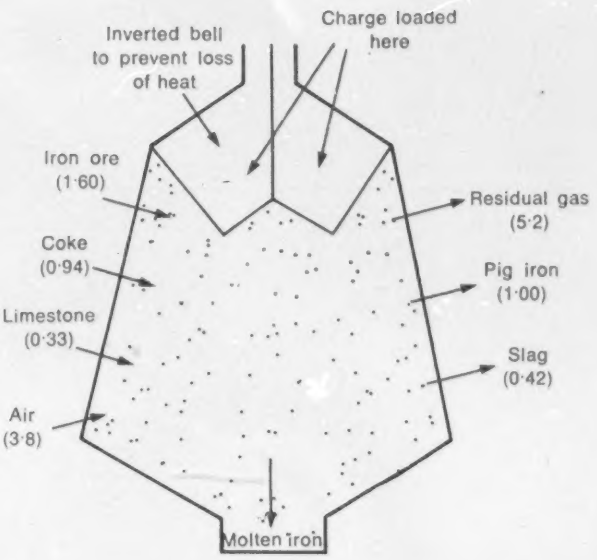


Figure 19.1: Blast furnace for pig iron—figures (in tonnes) represent amounts of material involved in manufacture of 1 tonne of pig iron

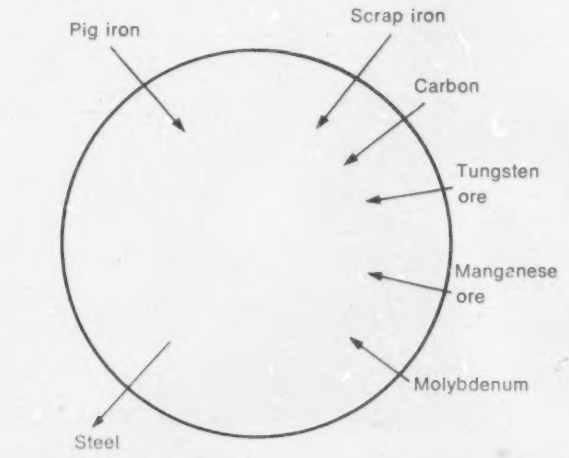


Figure 19.2: Steel-making furnace—quantities of material vary according to the type, quality and hardness of steel required, as does the nature of the additives

Where in Corbland would you locate, and why?
Where, if applicable, in a particular Corbland city would you locate, and why?

Figures 19.1 and 19.2 give further details about iron and steel manufacturing, and figures 19.3 and 19.4 give details of raw materials for furniture production. If you then try to keep the questions in 'Considerations' in mind, this will help you sort out an answer.

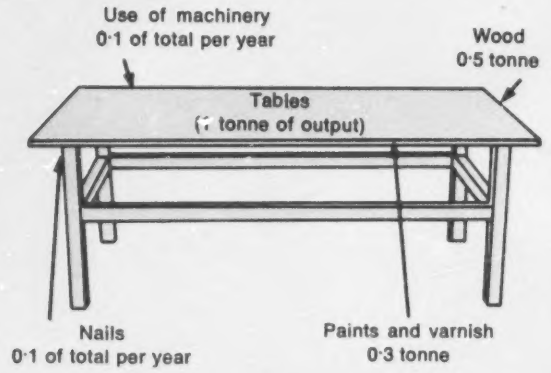


Figure 19.3: Furniture production—raw materials required per tonne of table output

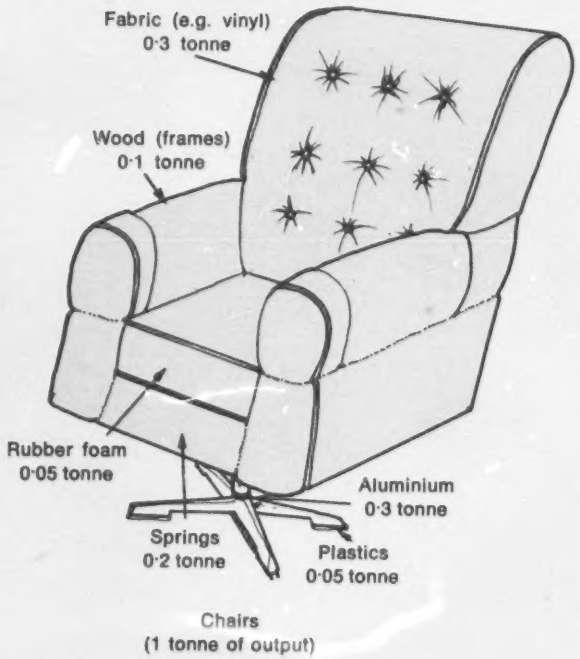


Figure 19.4: Furniture production—raw materials required per tonne of chair output

CONSIDERATIONS

Raw materials

1. Are these materials bulky, awkward and costly to transport?
2. Will these materials deteriorate quickly?
3. Are there sufficient quantities for production over a reasonable number of years?

Energy

1. Are large supplies of power required in the production process?
2. What source of power is most suited to production of the particular product?
2. What cost advantages exist between the use of coal gas, hydroelectricity and atomic energy?

Labour

1. Are large amounts of labour required?
2. In what proportions should labour be skilled, semi-skilled or unskilled? Male or female?
3. How valuable would it be to be near research institutions?
4. In what towns or cities are there relatively untapped supplies of labour?
5. What other firms will be competing for similar supplies of labour?
6. How stable is the labour force?
7. Is the environment attractive?

Market

1. What proportion of production could be sold locally?
2. How affluent is the local population?
3. Are there large cities nearby?
4. How bulky is the finished product?

Transport and communications

1. What types of transport are available?
2. What types of transport are most suitable for the movement of raw materials and finished products?
3. What linkages exist with seaports, other markets, and raw material locations?
4. Do freight concessions exist?
5. Do you need to provide your own transport routes and facilities? If so, what sort?

Political considerations

1. Is the area politically stable?
2. Does the government encourage or discourage industrial development?
3. Is the area being redeveloped?
4. To what extent is local planning legislation an advantage (or a hindrance)?

What about Corbland? Refer to figures 19.5 to 19.10, and to table 19.1.
Where would YOU build your factory?

Table 19.1: Statistics for Corbland

Type of statistic	CITY			
	Artan	Lantin	Dowell	Granville
1. DEMOGRAPHIC				
(a) Population size	149 000	1 500 000	1 100 000	2 000 000
(b) Unemployment				
(i) Males (% of male workforce)	1	2	1·5	2
(ii) Females (% of female workforce)	35	41	43	42
(c) Size of workforce (% of population)	60	63	62	70
(d) Secondary-school leavers per year (% of workforce)	2·5	3	2·5	3
(e) Retirement per year (% of workforce)	2	1·5	1·9	2·1
2. COSTS OF PRODUCTION				
(a) Setting-up costs				
(i) Land—purchase cost (per hectare)	$75 000	$100 000	$101 000	$125 000
(ii) Land rent or local government rates (per hectare per annum)	$125	$200	$205	$200
(iii) Land taxes (per hectare per annum)	$50	$75	$80	$85
(iv) Building costs				
Steel (per 1000 tonnes of output)	$1000	$1500	$1200	$1300
Furniture (per 1000 tonnes of output)	$500	$750	$650	$690
TOTAL SETTING-UP COSTS (*Steel producers:* remember there is a government subsidy of $1 for each $1 spent on setting up)				
(b) Labour costs				
(i) Wages (for both products, per man per annum)	$3120	$4000	$3600	$4200
(ii) Overtime (per man per annum)	$300	$350	$400	$410
(c) Costs of raw materials at point of extraction (see figure 19.5)	*Cities are not taken into account as cost is from point of extraction*			
(i) *Steel*				
(A) Iron ore	$500 per tonne			
(B) Coal (see also item 9 at end of table)	$50 per tonne			
(C) Limestone	$75 per tonne			
(D) Carbon	$10 per tonne			
(E) Tungsten (imported)	$250 per tonne			
(F) Manganese	$300 per tonne			
(G) Bauxite	$420 per tonne			
	Now take cities into consideration			
(ii) *Furniture*				
(A) Wood (per tonne)	$100	$120	$100	$130
(B) Nails (total per year)	$50	$50	$50	$50
(C) Machinery (total per year)	$29 000	$29 000	$29 000	$29 000
(D) Fabric (per tonne)				
—Vinyl	$60	$70	$80	$75
—Plastics	$50	$60	$65	$90
—Wool	$90	$70	$80	$80
(E) Steel structures (per tonne)	$600	$700	$400	$500
(F) Aluminium (per tonne)	$500	$600	$300	$400
(G) Rubber foam (per kg)	$30	$20	$20	$25
(H) Plastics (per tonne)	$110	$120	$110	$130
(I) Springs (per tonne)	$290	$260	$290	$300
(J) Glass (per tonne)	$40	$70	$60	$50
(K) Paints (per tonne)	$130	$170	$150	$170
(d) Energy costs (per 1000 tonnes of output)				
(i) Hydroelectricity	0·5 cents	0·7 c	0·8 c	0·7 c
(ii) Atomic generation	0·8 c	0·7 c	0·4 c	0·5 c

Type of statistic	TYPES OF TRANSPORTATION			
	Road	Rail	River	Air
(e) Transport costs (remember to take *time* into consideration)				
(i) Transport costs per type of raw material per kilometre per tonne				
Steel				
(A) Iron ore	40c	30c	10c	60c
(B) Coal	35c	25c	15c	75c
(C) Limestone	50c	40c	20c	50c
(D) Carbon	40c	35c	45c	50c
(E) Tungsten	50c	45c	30c	80c
(F) Manganese	60c	60c	40c	70c
(G) Bauxite	65c	40c	30c	80c
Furniture				
(A) Wood	40c	35c	20c	60c
(B) Nails (total per year)	15c	15c	15c	15c
(C) Machinery (total per year)	$1.00	$1.00	$1.00	$2.00
(D) Fabric (all types)	60c	40c	40c	80c
(E) Steel structures	50c	70c	20c	90c
(F) Aluminium	50c	70c	20c	95c
(G) Rubber foam (per kg)	45c	35c	45c	90c
(H) Plastics	70c	60c	70c	75c
(I) Springs	60c	50c	30c	95c
(J) Glass	$1.00	$1.20	$1.30	90c
(K) Paints	75c	55c	60c	90c

	CITIES			
	Artan	Lantin	Dowell	Granville
(ii) Intraurban transport costs per kilometre per tonne (the costs are to be computed for the areas within the extreme limits of each city) N.B.: Since every plant will need to use road transport within the city at some stage, this needs to be taken into account.	2c	1c	1·5c	1c
	Add this amount to that of **(e)** (i) above for roads			

3. CAPITAL AVAILABILITY	Artan	Lantin	Dowell	Granville
	Freely for steel and furniture	Freely for furniture; hard for steel	Hard for furniture; freely for steel	Freely for steel and furniture
4. COMPANY TAXATION	45% of profits are paid to the government as Company Tax in all areas. This can be reduced by re-investing some profit and by extra payouts to employees.			
5. MANAGERIAL SUPPLY	Low (possible immigration)	Low (possible immigration)	Low (possible immigration)	High (possible immigration)
6. MANAGERIAL COSTS	High	High	High	Medium
7. POLITICAL CONSIDERATIONS	Stable and helpful government of Corbland			
8. MARKET (see also figure 19.6)				
Steel	Low	Medium	Medium → Low	High
Furniture	Low	Medium → Low	Medium → Low	High
9. COST OF CONVERTING COAL TO COKE (1·5 tonnes coal → 1 tonne coke)	$15 per tonne of coke			

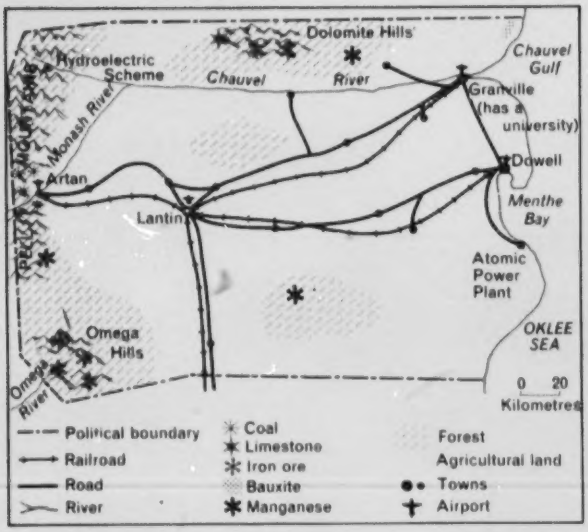


Figure 19.5: Corbland

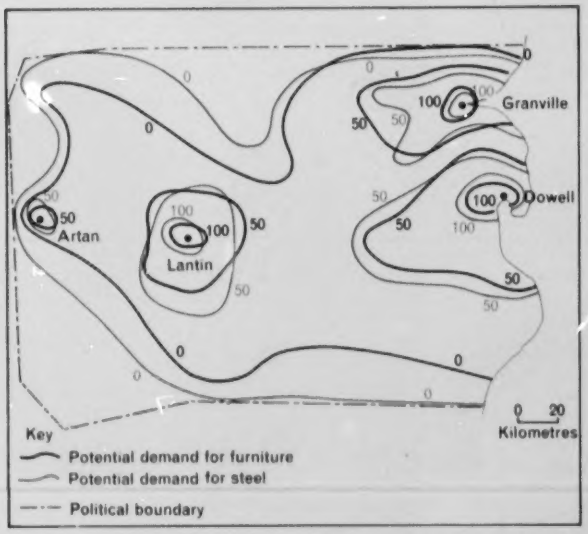


Figure 19.6: Potential demand for furniture and steel

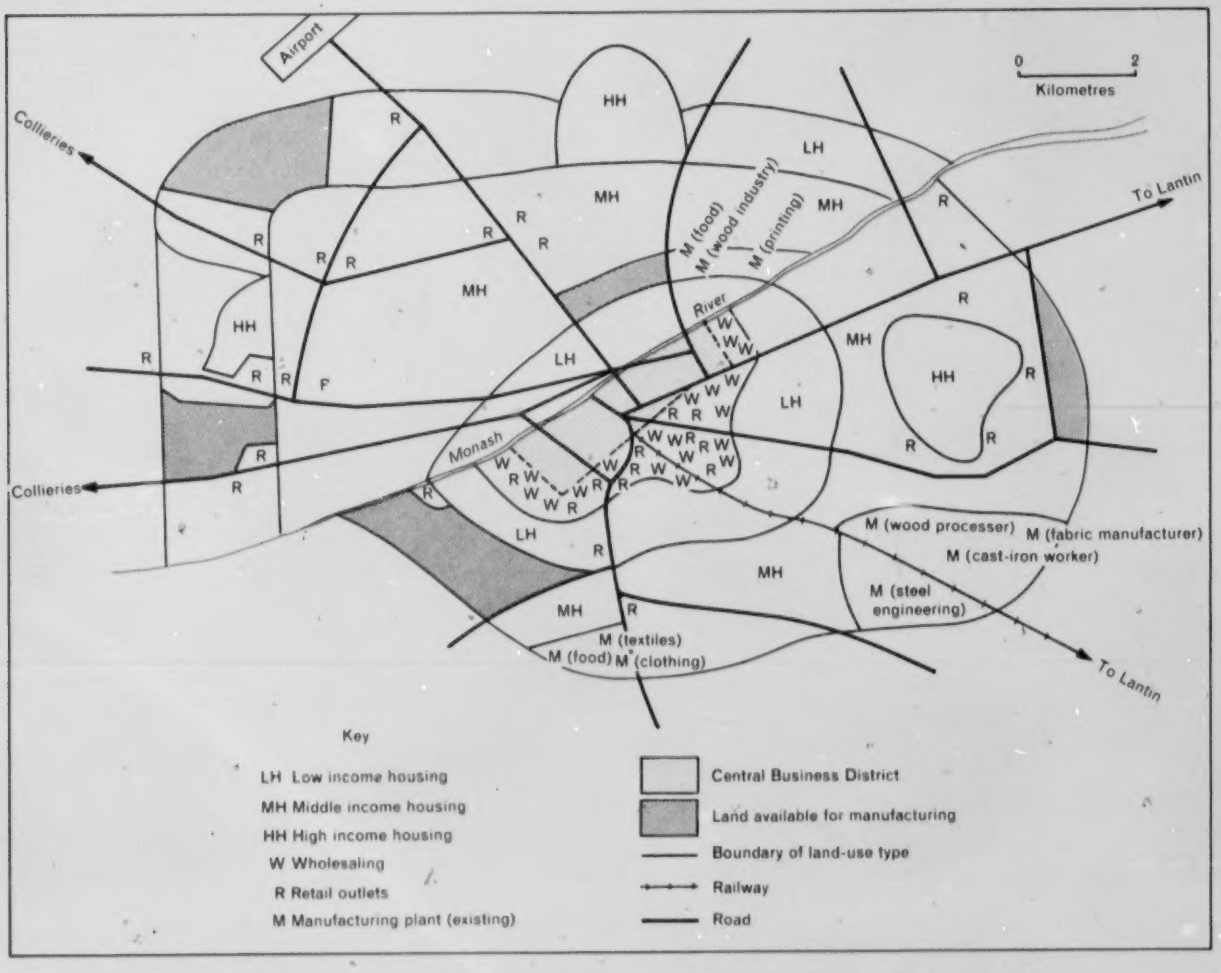


Figure 19.7: Spatial structure of Artan (based on the Artan Urban Planning Scheme and the actual structure)

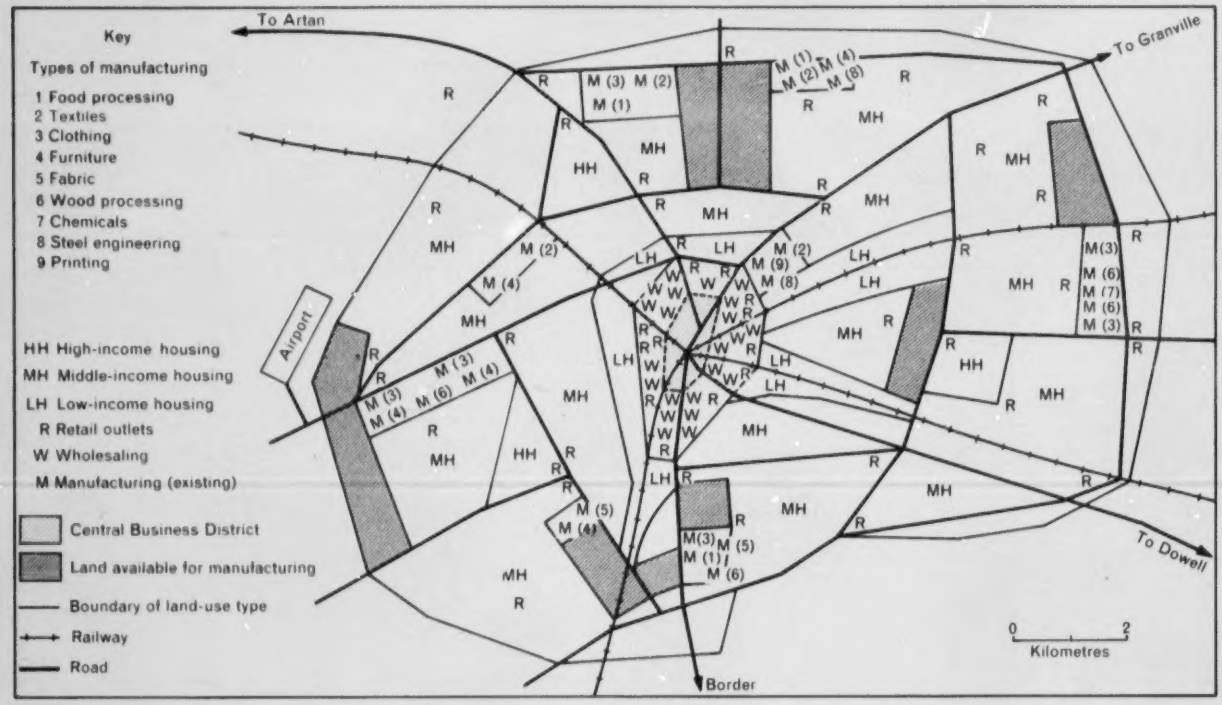


Figure 19.8: Spatial structure of Lantin (based on the Lantin Urban Planning Scheme and the actual structure)

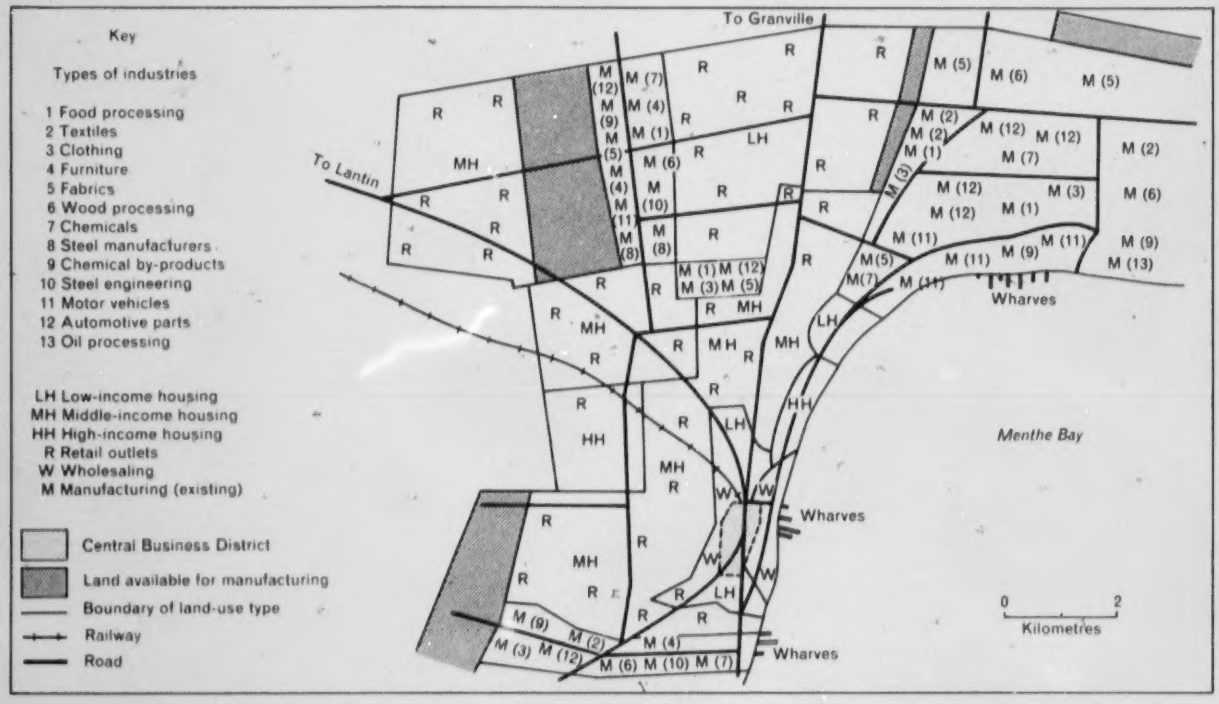


Figure 19.9: Spatial structure of Dowell (based on the Dowell Urban Planning Scheme and the actual structure)

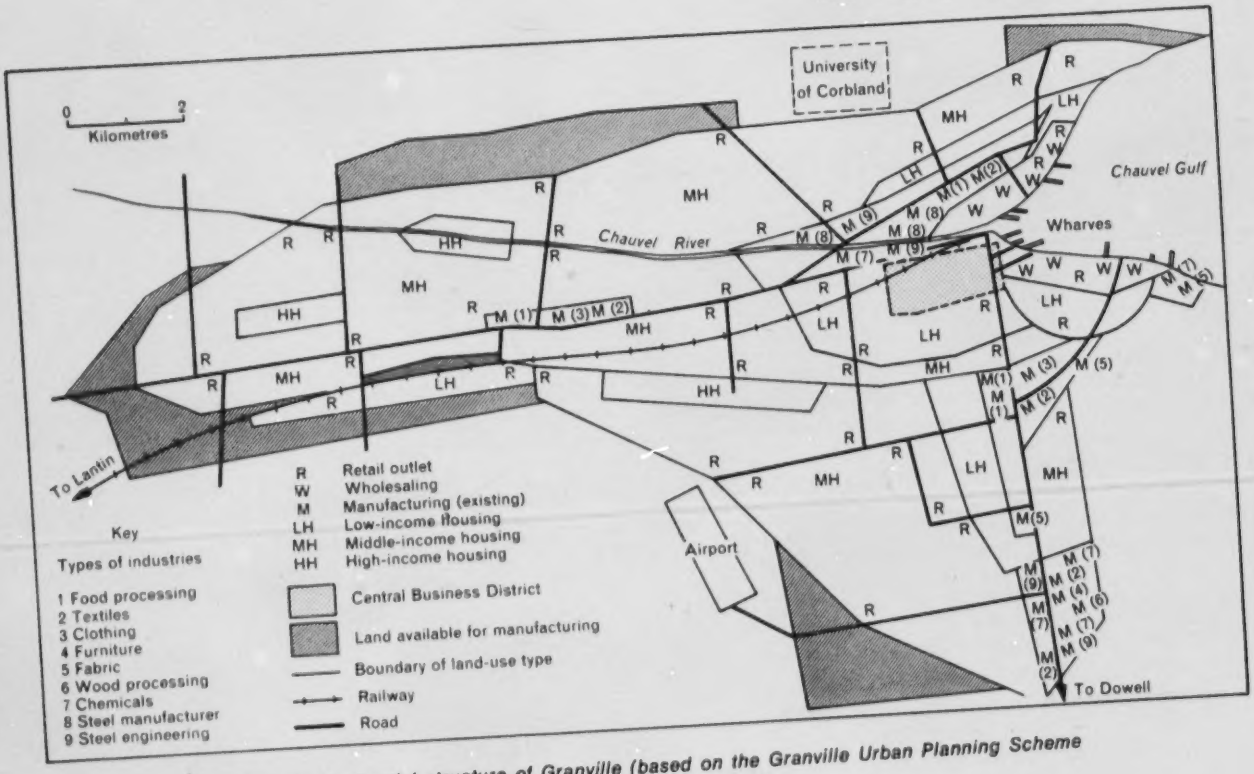


Figure 19.10: Spatial structure of Granville (based on the Granville Urban Planning Scheme and the actual structure)

20

Why not study a local factory?

In studies 14–19 you have been asked a large number of questions about factories. You should now be able to ask some questions of factory owners for yourself. One group of geography students in Queensland decided to explore the factories of their local area. You can learn how to study your local area by seeing what these students did and by thinking about the questions they asked.

Stage 1: planning

Most of the students had travelled along the Cunningham Highway between Ipswich and Brisbane and knew that many factories were located in this area. Because it was close to their school, they chose the section of the highway between Station Road, Darra, and Granard Road, Rocklea.

It would have been impossible to study all the factories in the area, so the students decided to make a detailed study of one factory and to study the general patterns of the other factories along the highway.

Which factory was to be chosen for the case study? Because it is such a large factory, the students decided to study the Darra cement works (figure 20.2), even though it is located off the highway. The students planned a morning field excursion to the study area, and wrote a letter to the manager of the Queensland Cement and Lime Company Ltd to arrange for the case study of the cement works. Working together, the class drew up a questionnaire so that they could record answers to important questions about the factory. A copy of the questionnaire was sent in advance to the manager of the factory. They then made copies of a base map (figure 20.3) showing the streets adjoining the section of the Cunningham Highway to be studied, and hired a bus to transport them to the Darra factory.

Stage 2: fieldwork

On the day of the field excursion, the busload of students, armed with maps and questionnaires, left school at 9.00 a.m. and travelled towards Darra. The first stop was at Granard Road, Rocklea. According to plan, the bus moved slowly along the Cunningham Highway and made frequent stops before it reached Station Road, Darra. The slow journey allowed the students to mark and name on their base map all the factories and areas of vacant land they could see from the highway. Figure 20.4 is an example of a completed map.

A little after 10 a.m. the bus arrived at the Darra cement works. The students went to the factory's cafeteria and recreation hall and were welcomed by the personnel officer of the company.

The personnel officer and the works manager told the students all about the factory. Many

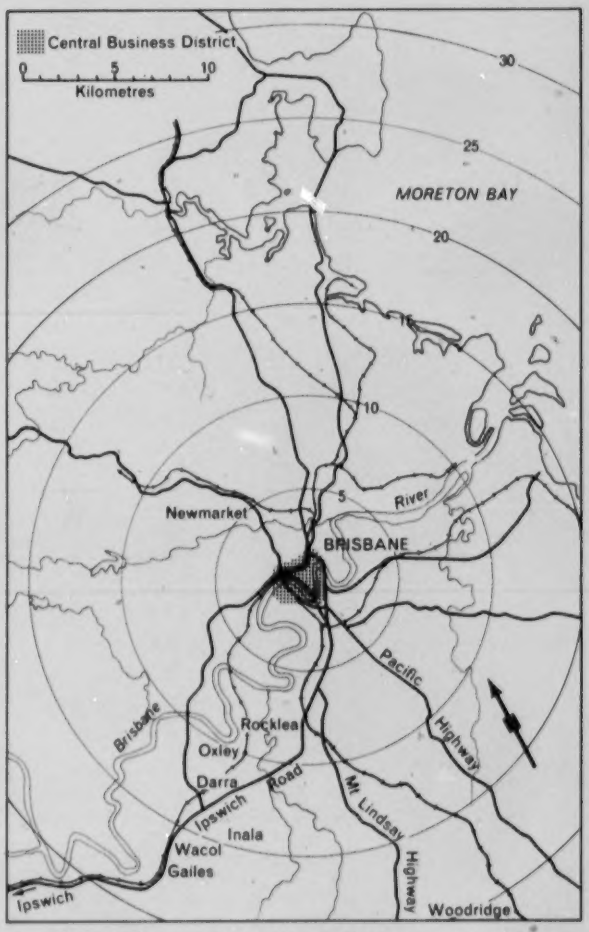


Figure 20.1: Location map showing the area studied

Figure 20.2: The Darra cement works

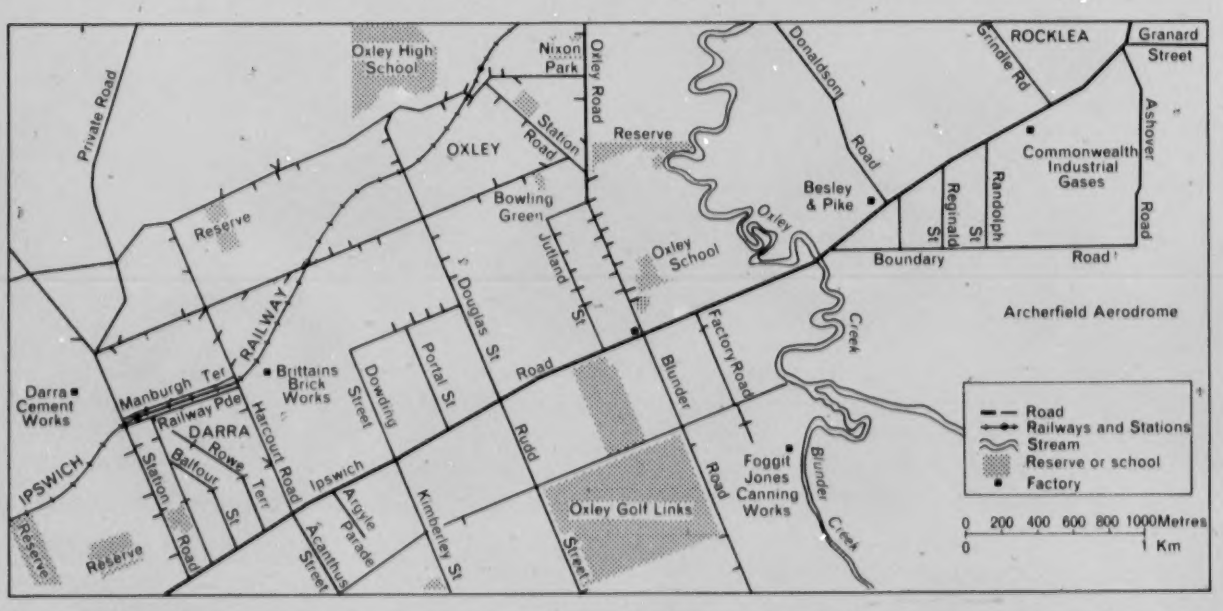
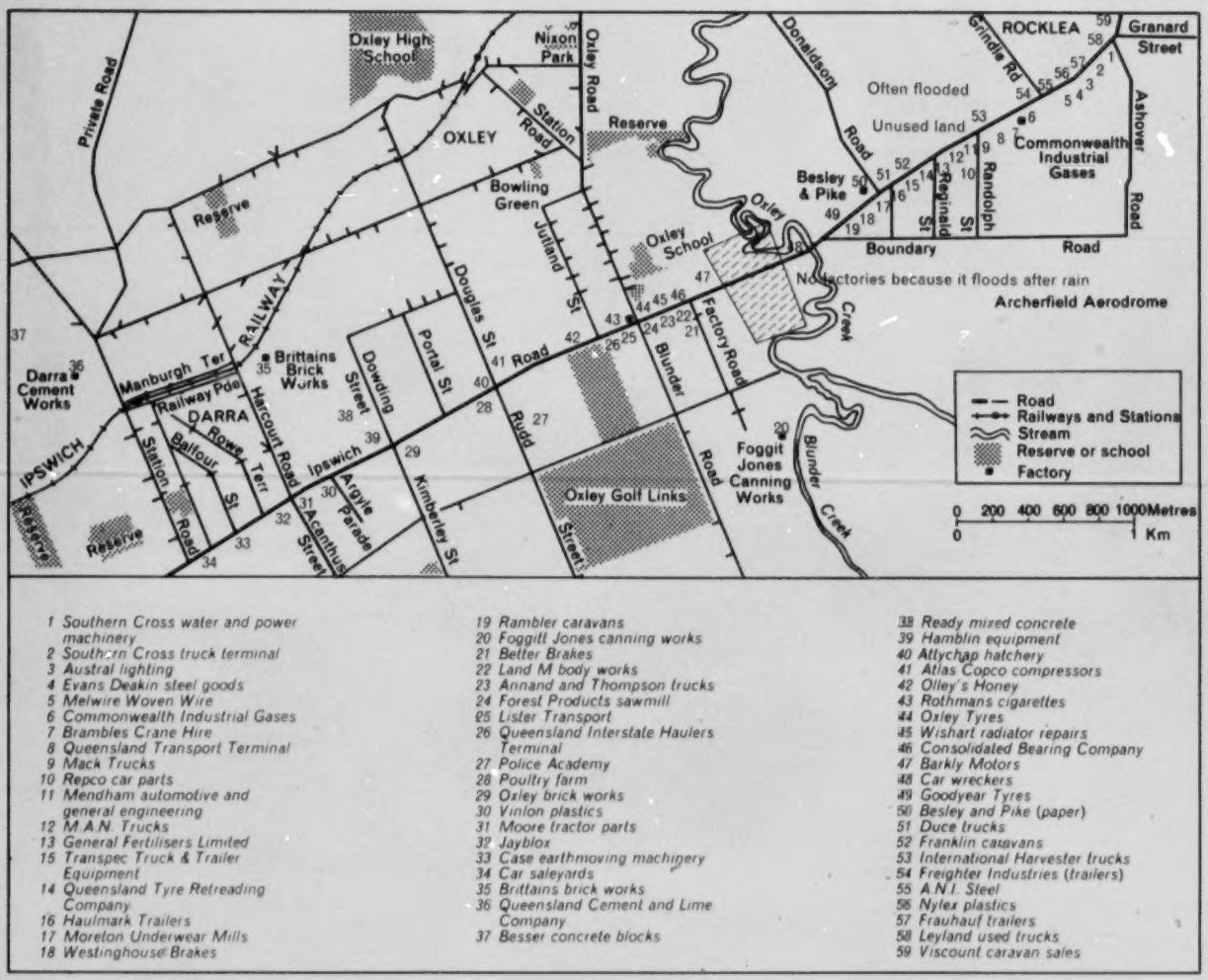


Figure 20.3: A copy of the base map for the field excursion



1 Southern Cross water and power machinery
2 Southern Cross truck terminal
3 Austral lighting
4 Evans Deakin steel goods
5 Melwire Woven Wire
6 Commonwealth Industrial Gases
7 Brambles Crane Hire
8 Queensland Transport Terminal
9 Mack Trucks
10 Repco car parts
11 Mendham automotive and general engineering
12 M.A.N. Trucks
13 General Fertilisers Limited
15 Transpec Truck & Trailer Equipment
14 Queensland Tyre Retreading Company
16 Haulmark Trailers
17 Moreton Underwear Mills
18 Westinghouse Brakes
19 Rambler caravans
20 Foggitt Jones canning works
21 Better Brakes
22 Land M body works
23 Annand and Thompson trucks
24 Forest Products sawmill
25 Lister Transport
26 Queensland Interstate Haulers Terminal
27 Police Academy
28 Poultry farm
29 Oxley brick works
30 Vinlon plastics
31 Moore tractor parts
32 Jayblox
33 Case earthmoving machinery
34 Car saleyards
35 Brittains brick works
36 Queensland Cement and Lime Company
37 Besser concrete blocks
38 Ready mixed concrete
39 Hamblin equipment
40 Attychap hatchery
41 Atlas Copco compressors
42 Olley's Honey
43 Rothmans cigarettes
44 Oxley Tyres
45 Wishart radiator repairs
46 Consolidated Bearing Company
47 Barkly Motors
48 Car wreckers
49 Goodyear Tyres
50 Besley and Pike (paper)
51 Duce trucks
52 Franklin caravans
53 International Harvester trucks
54 Freighter Industries (trailers)
55 A.N.I. Steel
56 Nylex plastics
57 Frauhauf trailers
58 Leyland used trucks
59 Viscount caravan sales

Figure 20.4: One student's completed map with key

students had questions to ask, and as the men spoke the students filled in their questionnaires. One student asked a very good question, and this question and its answer were added to the bottom of the questionnaire. The question was: 'If you were building your factory again, where would you build it? Would it be at Darra?' Can you think of any other good questions that could have been asked?

Below is an example of a completed questionnaire.

Factory questionnaire

Q 1: What is the name of the factory?

A: The Darra cement works. The official name is the Queensland Cement and Lime Company Limited, Darra.

Q 2: What does the factory produce?

A: The factory produces cement, which is sold in bags or in bulk loads.

Q 3: What are the raw materials, and from where do they come?

A:
(i) Coral from Moreton Bay
(ii) Sand from local sources (Gailes and Wacol)
(iii) Shale from local sources (Wacol)
(iv) Ironstone from northern New South Wales
(v) Gypsum from South Australia
(vi) Water from the Brisbane River and from the Brisbane city water supply
(vii) Coal from the Ipswich coalfields
(viii) Much electricity is also used. This is generated at Swanbank on the Ipswich coalfields. The personnel officer said most of the raw materials are bulky and costly to transport, so local supplies are used where possible.

Q 4: What happens to the raw materials?

A: The coral is crushed and mixed with shale, sand, ironstone and water to form a 'slurry'. This is fed into revolving kilns or ovens, which are heated by burning coal. Water and gases are removed, and a solid mass is taken from the kilns and cooled. Gypsum is added, and the material is then ground into powder—this is cement. Some of the cement is bagged, the remainder being stored in bulk.

Q 5: Where is the product sold?

A: 'Ace' brand cement from the Darra factory is marketed in southern Queensland and northern New South Wales. Over half of this is sold to firms building dams, factories and office blocks, to ready-mixed cement companies, and to companies that make cement products (for example, 'Rocla' concrete pipes, 'Hardie' fibro sheets and 'Besser' and 'Jayblox' concrete blocks). Bagged cement is sold to hardware stores.

Q 6: How are the raw materials and the products transported?

A: In the early years the nearby railway line was the only transport used, but today both road and rail transport are used. River transport is also important—two boats bring coral from Moreton Bay to the company's wharf at Oxley. A conveyor belt about 3 kilometres long carries the coral from the Oxley wharf to the cement works.

Q 7: How many persons work in the factory? How skilled are the workers? Where do they live?

A: Four hundred and fifty persons work in the factory. These include engineers, sales staff, office workers, labourers, cafeteria staff, a greenkeeper for the factory's bowling green, and many others. Most workers live near the factory and many live in the suburb of Inala. Others come from Ipswich, Newmarket and Woodridge. Many workers travel by train.

Q 8: How is any waste material disposed of? Are there any environmental problems that are caused by the factory?

A: Dust is the main waste material. The company tries to stop dust from polluting the atmosphere and has spent over $1 million over three years on equipment to collect dust. Much of the dust is fed back into the kilns to make more cement, and some dust and other waste is dumped on a vacant area of land owned by the company. The risk of air pollution is likely to be greatest in winter when dust and smoke would remain close to the ground and would be spread over the city of Brisbane by westerly winds.

Once the factory was a small one on the fringe of Brisbane and there were few houses near it. Today the factory is a large one surrounded by houses. The company is very aware of environmental problems.

Q 9: Why was the factory located where it is, rather than elsewhere?

A: The factory was built in 1914. At that time Darra was a good location for a cement works—it was close to limestone (then obtained from near Warwick), sand, shale and coal. Water could be obtained from the river, and there was plenty of room for the factory because it was on the edge of Brisbane. The factory was close to customers in Brisbane, and the railway line ran near it.

Q 10: If you were building your factory again, where would you build it? Would it be at Darra?

A: The personnel officer said that the company would have to study many factors before it could decide whether to build again at Darra or to build the factory somewhere else. The main factors the company would study carefully are:

(i) raw materials
(ii) markets
(iii) transport
(iv) environmental problems.

A situation close to the mouth of the Brisbane River would have many locational advantages.

At 11 a.m. the students thanked the company representatives and left the cement works for the trip back to school. As the bus drove out of Darra, they took special notice of the housing areas near the cement works and watched for examples of factories that might use Darra cement as a raw material.

Look at figures 20.2 and 20.5. Describe the area around the Darra cement works. Examine figure 20.6. What product does Jayblox produce? What is the main raw material? Find the location of the Jayblox factory in figure 20.4. Can you explain this location?

Stage 3: further activities

After the field study, there were many things still to do. The students tried to summarise the pattern of industries along the Cunningham Highway by classifying or grouping the individual firms. One student put all the factories into five classes:

1. transport factories and sales places
2. chemical and clothing factories
3. cement and brick works
4. engineering factories
5. food factories

Figure 20.5: Housing in Darra, with the cement works in the background to the right

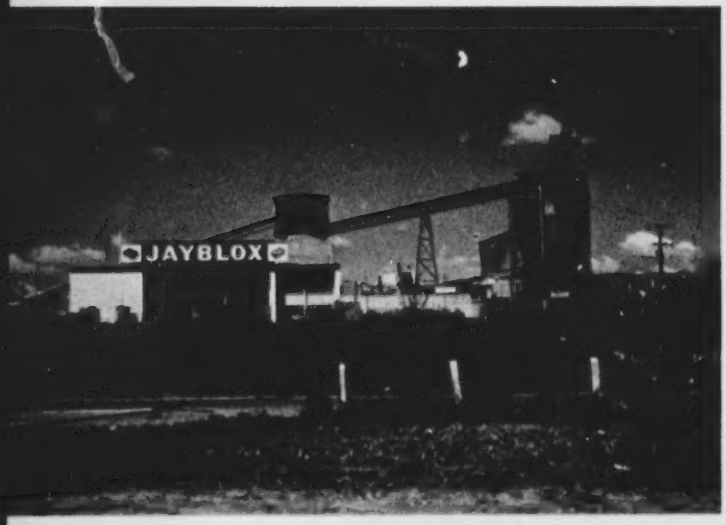


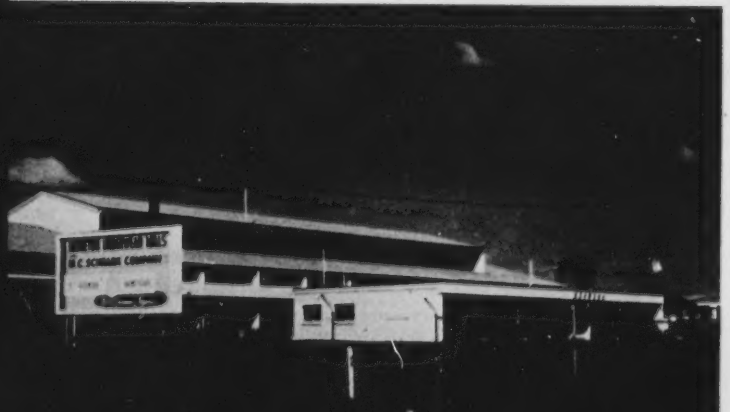
Figure 20.6: The 'Jayblox' factory

Figure 20.7: The Moreton Underwear Mills

Figure 20.8: The Case saleyard

Figure 20.9: Brittains Brickworks Proprietary Limited

Figure 20.10: Why do governments try to attract industry to particular areas?



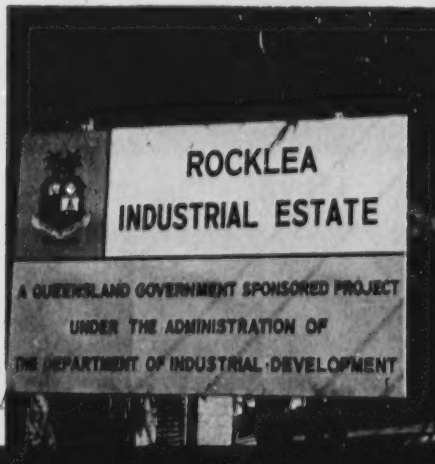


Figure 20.11: Open spaces, natural vegetation and a power supply are features of preplanned industrial estates

Look at figures 20.7, 20.8 and 20.9. Into which classes would you place these factories? On figure 20.4, find examples of engineering and food processing factories.

Why were so many factories located along the Cunningham Highway? The students decided that closeness to Brisbane and the four-lane highway were important factors. Some of the class carried out a traffic survey after school at the Granard Road intersection. Statistics were also obtained from the Traffic Planning Branch of the Main Roads Department in Brisbane.

Some students were very interested in the pollution problem. They obtained information about fallout in the area by reading the annual report of the Air Pollution Council of Queensland. Other students wanted to find out more about the raw materials of the cement works at Darra. They studied geological maps and obtained information about the West Moreton coalfields from the Queensland Department of Mines. The class teacher helped the group to find out about the population changes in the area. Figures were obtained from the Bureau of Census and Statistics.

Finally, the students started to organize another visit to factory areas, this time in planned industrial estates at Rocklea and Wacol (figures 20.10 and 20.11). What is an industrial estate? What are the questions you would ask if you were studying an industrial estate?

If factories are located in your local area, what are the questions you would ask about them and what are the things you would do to study them?

21

Different colours?

Since World War II, one of the most widely publicised issues on the global scene has been the 'colour problem'. We hear about the practices of 'apartheid', belief in white, brown, black or yellow supremacy, distrust of anybody whose skin is a different colour. (Is this really a new problem?)

But distinctions made on the basis of colour are only part of the story. Article 2 of the Universal Declaration of Human Rights, adopted by the General Assembly of the United Nations in 1948, states: 'Everyone is entitled to all the rights and freedoms set forth in this declaration, without distinction of any kind, such as race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status.' The declaration, then, recognises that there are eight ways in which one group of men may set themselves against another. You should be able to think of at least one example of each of these eight kinds of discrimination. In our newspapers, examples of one type or another are reported almost every day.

However, there should be just as much concern for those situations where there appears to be little conflict. With the global population expanding so rapidly, men must learn to live together in a world where the amount of land per person is rapidly diminishing. Situations that are free of serious conflict may provide useful clues in the search for ways to achieve more harmonious relations between different groups.

Case study 1: Fiji

Fiji consists of about 800 islands, the largest of which are Viti Levu (10 385 square kilometres) and Vanua Levu (5 535 square kilometres). (See figure 10.1, page 82.) Once a British Crown Colony, Fiji became independent on 10 October 1970.

In December 1969, the estimated population of Fiji was 526 725, consisting of people of Polynesian, Melanesian, Indian and European origin. Many of them are farmers who cultivate the land to produce a wide variety of crops. Two of these crops account for approximately three-quarters of the area under cultivation, as you have seen in study 10.

Examine figures 21.1, 21.2 and 21.3. What problems can you see developing in this situation?

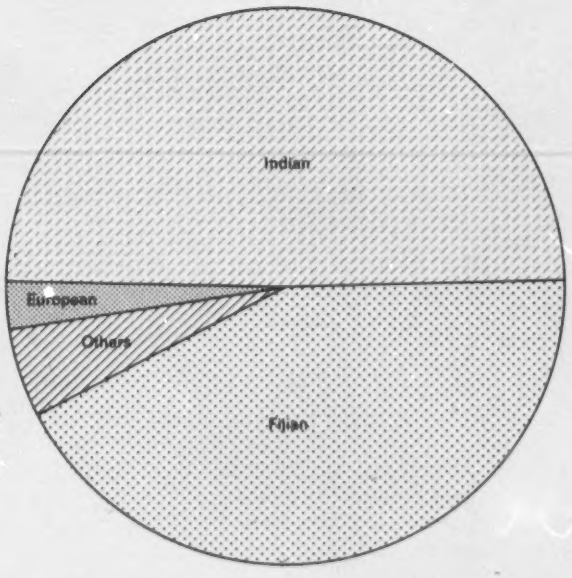


Figure 21.1: Ethnic composition of Fiji's population, 1969

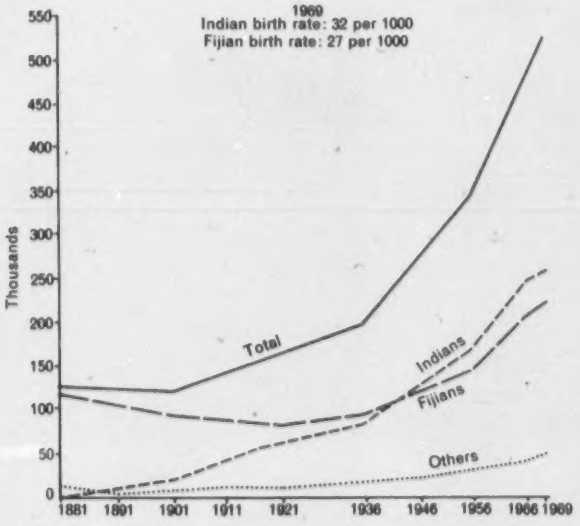


Figure 21.2: Population growth, Fiji, 1881–1969

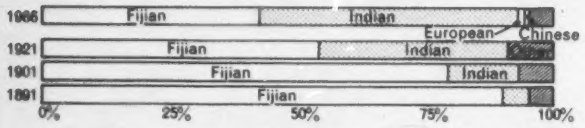


Figure 21.3: Ethnic composition of Fiji's population, 1891–1966

When did Indians come to Fiji?

In the late nineteenth century, the Colonial Sugar Refining Company (Australia) decided to establish a sugar industry in Fiji to prevent competition from developing, but was faced with the problem of labour, as the Fijians, who were communal land owners, were not interested, nor encouraged by the authorities, to work as plantation labourers. During the nineteenth century, Indians were encouraged to migrate to British colonies to work as labourers; some had already been brought to Fiji to work on cotton and coconut plantations.

Indians were transported free to Fiji to work for five years as directed, after which they could pay their fare back to India or work for another five years in Fiji anywhere they chose, after which they could have a free passage home or remain in Fiji as free settlers.

When immigration of Indian labourers ceased in 1916 and all indentures terminated in 1920, labour shortage and economic problems resulted in a major reorganisation of the method of land leased at low rentals to the Indians. Farms averaged about four hectares, as it was considered that this size was sufficient for a man and his family to farm for sugar, grow vegetables and rice, and graze a cow. Indians also obtained land from other sources, and thus the present pattern of land utilisation was established.

Fijians cultivated less land than the Indians because they were generally not attracted to the demanding and constant work of cane farming and their communal traditions were opposed to the idea of individual effort and reward.

A. G. Lowndes (ed.), *South Pacific Enterprise* (Sydney: Angus & Robertson, 1956), pp. 33–4

Thus, by 1930, Fiji had what is called a plural or multiracial society. One might have expected that the Indian newcomers, in a plural society like this, would be looked down on and have a lower status than the indigenous Fijians.

Look at figures 21.4–21.6, which show both Fijian and Indian inhabitants of Fiji.

The traditional way of life of the Fijian was that of a subsistence cultivator, fishing being important for the coastal village dwellers. The communal society was paramount: land was held in common, any villager being entitled to use part of it, although the actual farming of the plots was not done on a communal basis. Some aspects of the Fijian way of life can be observed in figures 21.7 to 21.12.

In contrast, the readiness of the Indian to leave his homeland and work as an agricultural labourer was a significant factor not only in establishing the Indian as the commercial canegrower, but in determining, to a large extent, methods of cultivation used today. Aspects of culture introduced by Indians can be seen in figures 21.13 and 21.14.

What evidence is there in these photographs that indicates the differing economic status of Fijians and Indians?

As you saw in study 10, sugar cane is the major commercial crop in the Fijian islands. Examine figures 21.15, 21.16 and 21.17. Compare the provinces where either of the two ethnic groups has more land with the map of types of production and the sugar cane map. What differences are there between provinces where Fijians have more land and those where Indians have more land? Compare your findings with figure 21.18. Which of the two ethnic groups appears to have more Class 1 land, especially that suited to crop farming?

Both groups are dependent on agriculture, but as you have seen, both here and in study 10, there are many differences in the types of farming. What further information is provided by table 21.1?

Table 21.1: Types of crops

Fijians	Indians
bananas	sugar cane
cacao	vegetables
coconuts	rice

If you look back to study 10, especially figure 10.15, you will find other differences between the two groups. The colonial policy of the British was intended to ensure that the land was owned by the Fijians. In Fijian society individuals did not own land, and as a result 1 516 000 hectares or 84 per cent of the land area is Fijian communal land *(mataqali)* or is administered by the Native Lands Trust Board. Only Fijians have access to this land. How could the situation illustrated in figure 10.15 affect relations between the two groups?

As a result of these developments in Fijian society, the Indian population is largely confined to the two main islands, whereas the Fijians are widely distributed over all the islands. What features of the situation in Fiji could lead to the differences between Fijians and Indians shown in tables 21.2 and 21.3?

Table 21.2: Ratio of Indians to Fijians in secondary and tertiary occupations

Secondary	17:1
Skilled workers	2:1
Construction	11:1
Commerce	8:1
Clerical	2:1
Transport	7:1

Figure 21.4: A Fijian and two Indian women in Suva

Figure 21.5: Fijian boys in the highlands

Figure 21.6: An Indian girl near Lautoka

Figure 21.7: A Fijian village on the Coral Coast

Figure 21.8: Fijian women fishing—what might the men be doing?

Figure 21.9: A Fijian village in the highlands

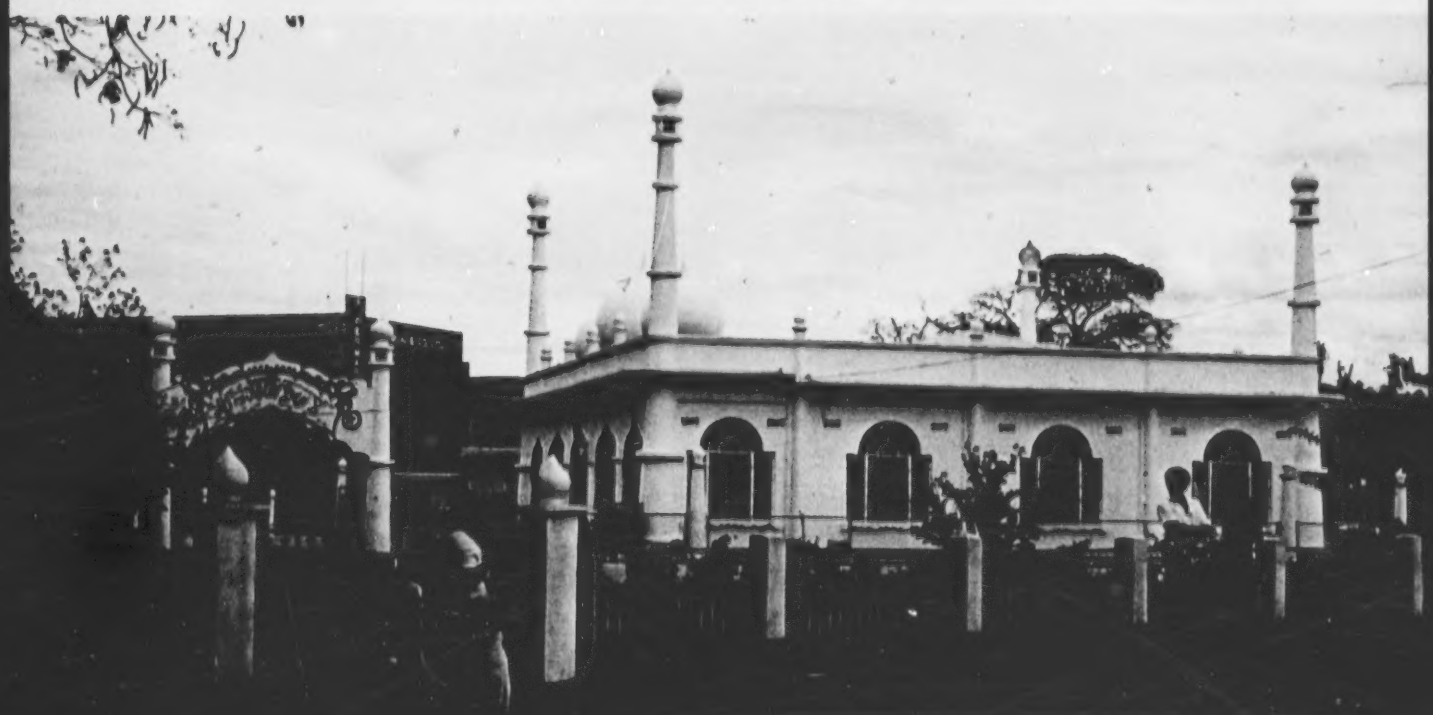
Figure 21.10: A village ***bure****. Try to identify the materials used in its construction*

Figure 21.11: Cultivating dalo—refer to study 10 if you need more information on traditional agriculture

Figure 21.12: A Fijian market stall—what produce can you identify?

Figure 21.13: Indian sweet-sellers in Ba township

Figure 21.14: An Indian mosque in Ba



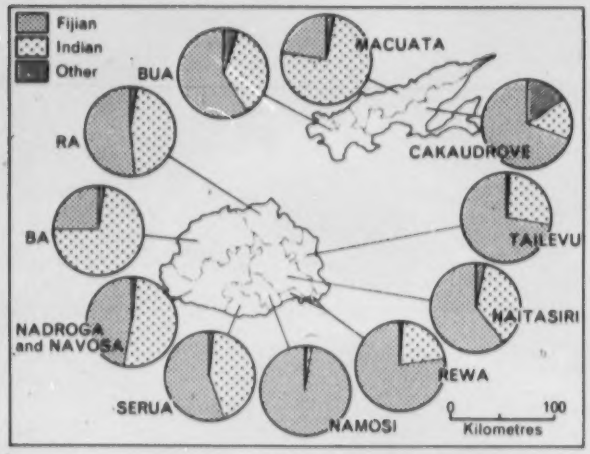


*Figure 21.15: Fiji—ethnic origin of landholders, by province (source: **Report on Census of Agriculture, 1968**)*

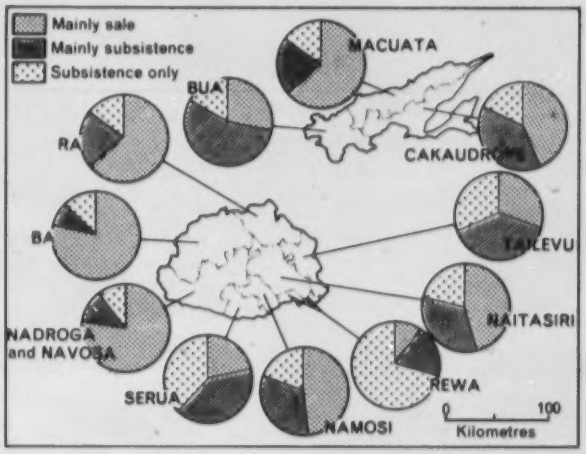


*Figure 21.16: Fiji—landholdings according to type of production, by province (source: **Report on Census of Agriculture, 1968**)*

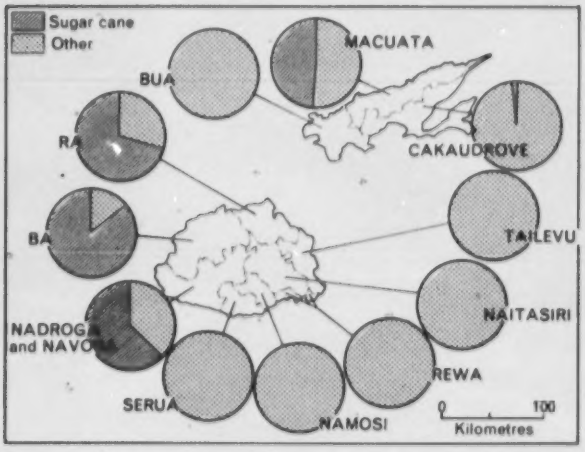


*Figure 21.17: Fiji—area under sugar cane, by province (source: **Report on Census of Agriculture, 1968**)*

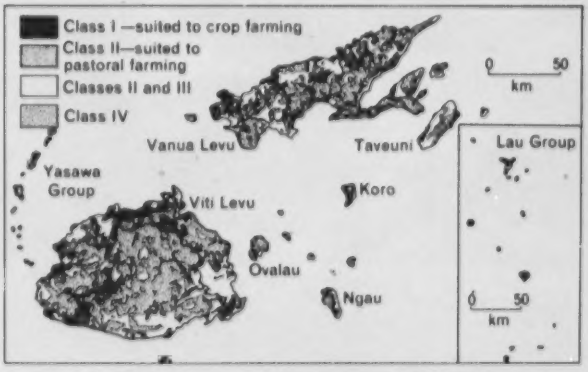


*Figure 21.18: Fiji—land classification (after Twyford and Wright, **The Soil Resources of the Fiji Islands, 1965**)*

Thursday, August 24, 1972
शान्ति दूत
SHANTI DUT
THE LEADING HINDI WEEKLY IN THE SOUTH PACIFIC
Price 5c
Narayan Ltd.
सी. एस. आर. कम्पनी के जमीनों में बसे असामियों को प्रथम बार सही टायटल

Figure 21.19: Indian newspaper

NAI LALAKAI

LOTULEVU, 24 NI OKOSITA, 1972

MH
Yaya digitaki ni mua ni macawa

VAKADONUI ME DURI NA KABANI VOU NI SUKA

Figure 21.20: Fijian newspaper

Table 21.3: Degree of urbanisation

Fijians	Indians
22%	30%

Because of the scattered and more rural nature of the Fijian population, Fijian schools are smaller and more isolated. Together with lack of financial resources in subsistence rural areas, this leads to lower standards of educational opportunity and achievement.

Thus Fiji has a number of social problems caused by economic differences between different groups of people; this is not basically a 'colour' problem —it implies that economic differences cause social differences. Do they and should they? Both groups have different complaints. How would you go about remedying one group's grievances without hurting the other group? Why might two different ethnic groups experience difficulty in living together? Do figures 21.19 and 21.20 give you a clue to what one answer might be?

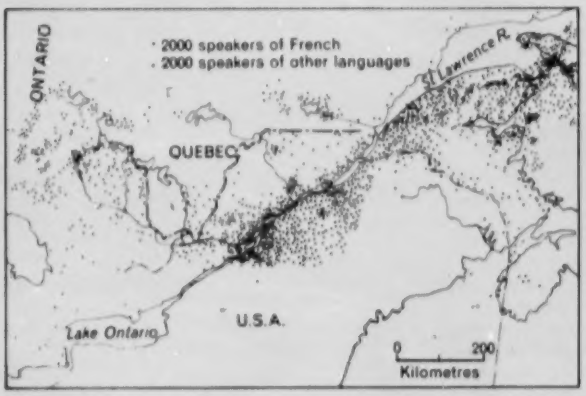


*Figure 21.21: Language in south-eastern Canada, 1961 (after H.S.G.P. Unit 3: **Cultural Geography**)*

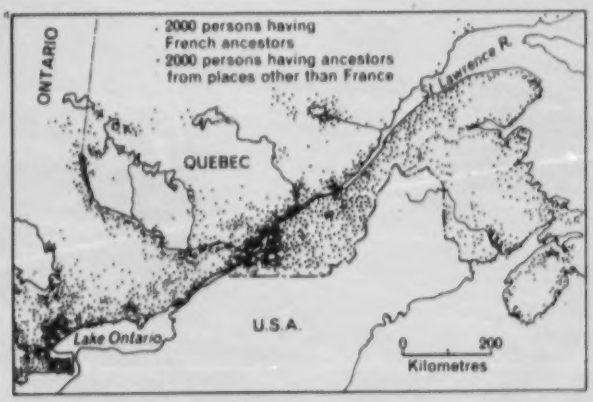


*Figure 21.22: Ethnic origin in south-eastern Canada, 1961 (after H.S.G.P. Unit 3: **Cultural Geography**)*

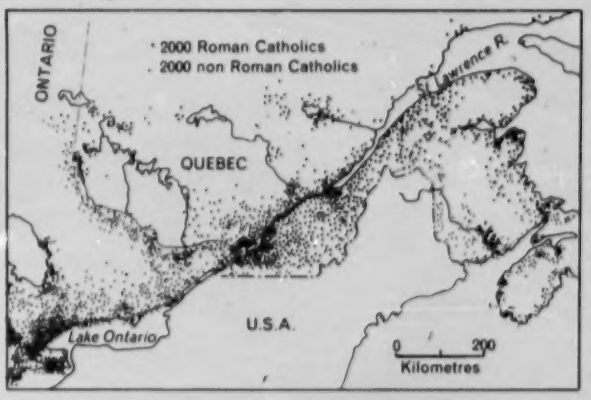


*Figure 21.23: Religion in south-eastern Canada, 1961 (after H.S.G.P. Unit 3: **Cultural Geography**)*

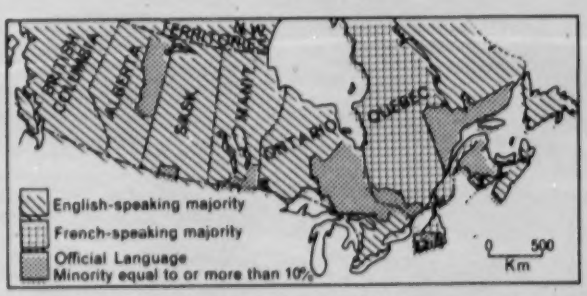


Figure 21.24: Areas where the official language minority is equal to or more than 10 per cent of the population (after Royal Commission on Bilingualism and Biculturalism)

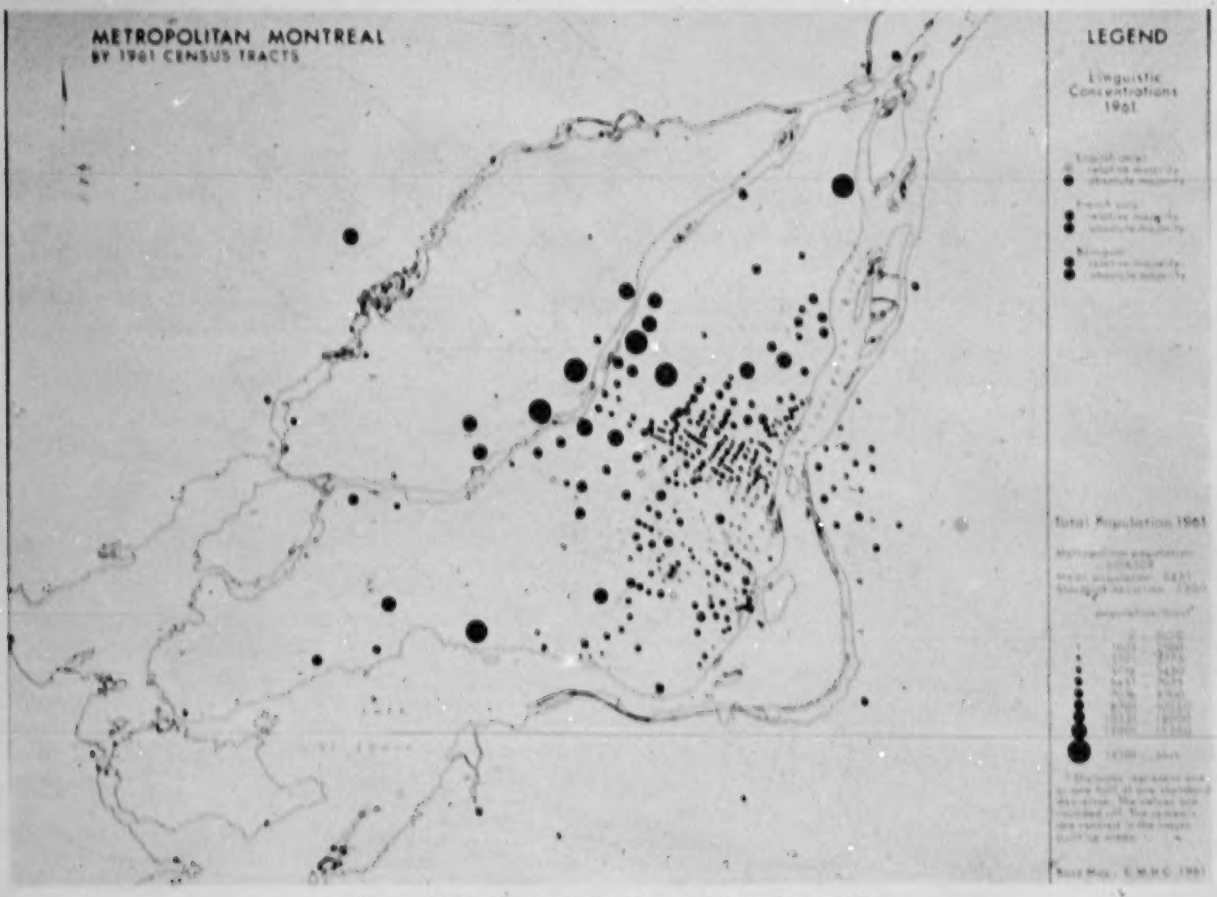
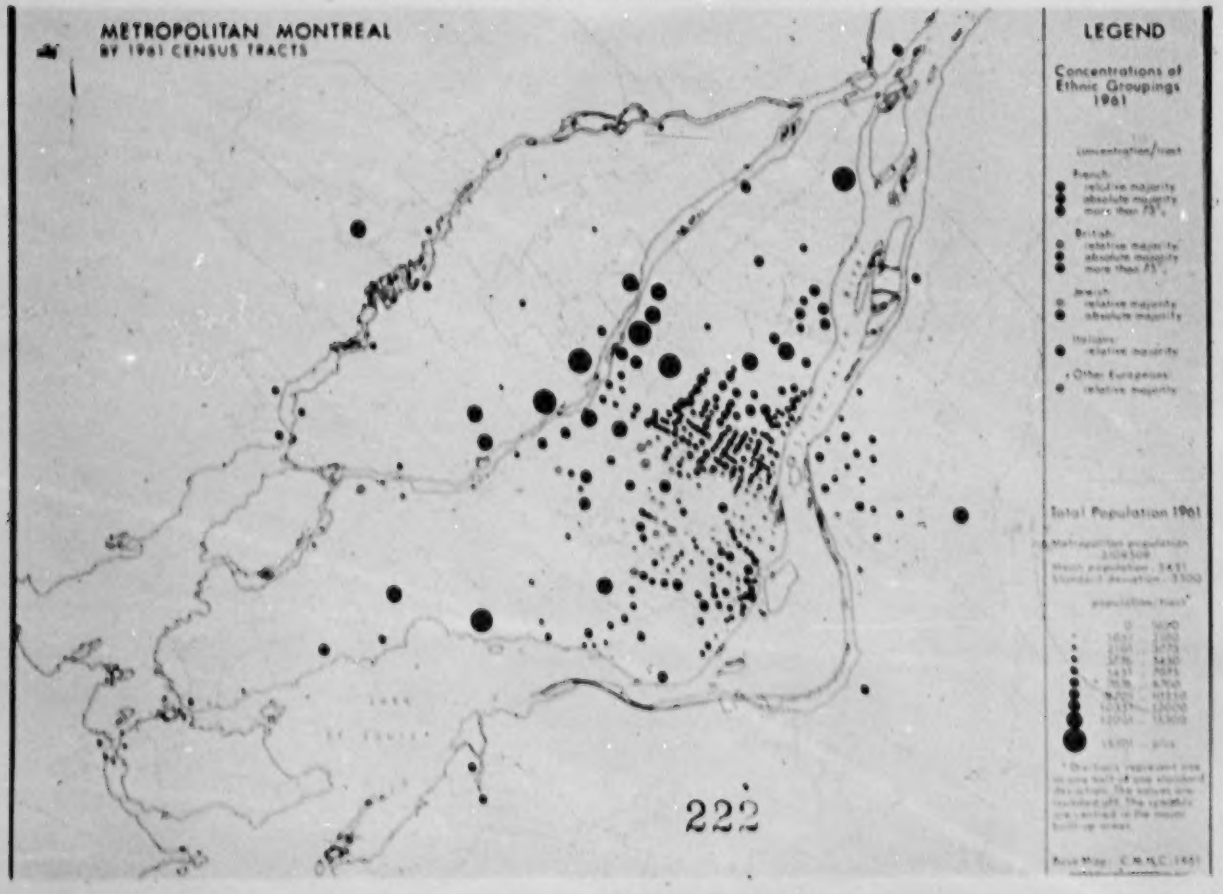


Figure 21.25: Montreal—linguistic concentrations, 1961

Figure 21.26: Montreal—concentrations of ethnic groupings, 1961



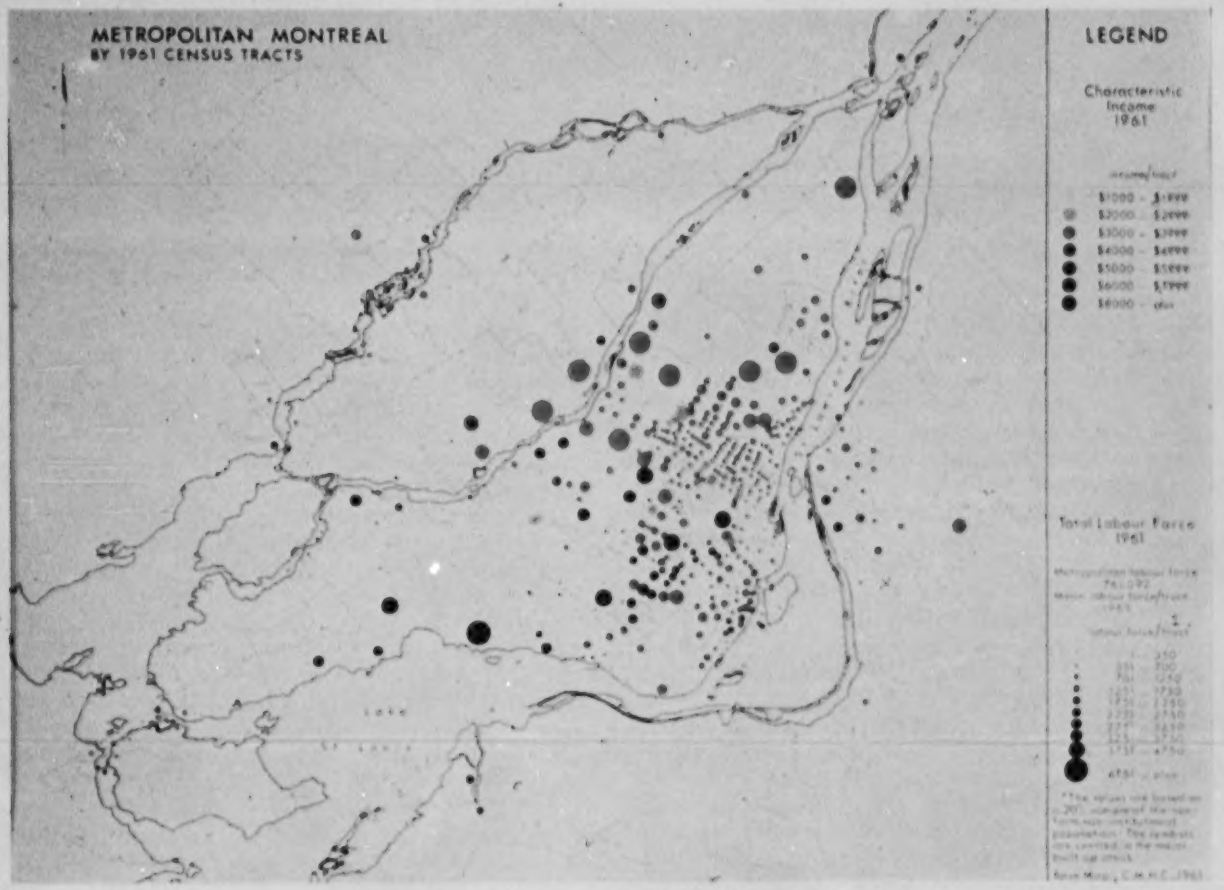
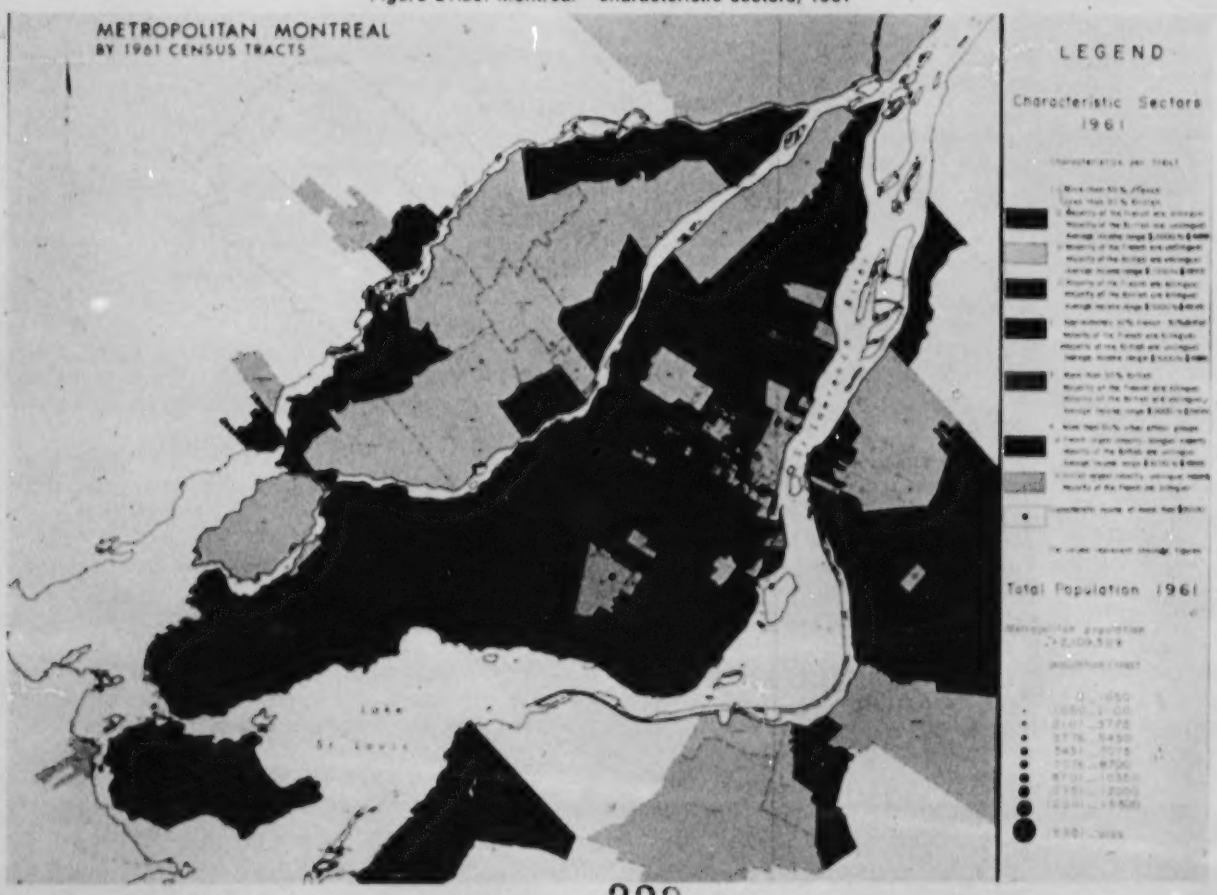


Figure 21.27: Montreal—characteristic income, 1961

Figure 21.28: Montreal—characteristic sectors, 1961



Case study 2: Canada and Montreal

The first European settlers in the area of North America that is now called Canada were from France, and from 1608 to 1763 French settlement held sway:

1608—Quebec founded
1634—Trois Rivières founded
1642—Montreal founded
1740—Settlement was a line of villages along the St Lawrence to just west of Montreal
1756–63—Britain defeats France in Seven Years War; all French possessions in eastern half of North America become part of British empire
1783—American Revolution concluded by Treaty of Versailles; influx into British North America of United Empire Loyalists, other American colonists, and British immigrants, settling largely in Ontario.

Examine a detailed map of Canada and compare the names of the towns and other features in the provinces of Quebec and Ontario. What do they indicate about the origin of the people who named them?

In 1961, the total population of Canada was 18 238 247 and the number of French-speaking Canadians was 5 540 346. In Quebec the number of French-speaking Canadians was 4 241 354, while the total population of Quebec was 5 259 211. Draw two pie-diagrams to illustrate the proportion of French-speaking Canadians in the whole of Canada and the proportion in Quebec. What does this indicate about the concentration of French-speaking Canadians in Canada? Do figure 21.21 and table 21.4 support your answer?

Table 21.4: Percentage of Canada's population of various ethnic* origins, 1881–1961

	1881	1901	1911	1921	1931	1941	1951	1961
British	58·9	57·0	55·5	55·4	51·9	49·7	47·9	43·8
French	30·0	30·7	28·6	27·9	28·2	30·3	30·8	30·4
Other groups	10·1	12·3	15·9	16·7	19·9	20·0	21·3	25·8

**Ethnic group:* a term referring to those who share a common origin, mainly of biological descent

Thus Canada is a bicultural country and, as both the English and the French language are officially recognised, it is also a bilingual country. Whereas, in some countries, such cultural diversity is frowned upon, it is officially encouraged in Canada. Such official views reflect the fact that Canadians of French ethnic origin consistently retain their mother tongue and culture.

During the 1960s, especially in the province of Quebec, French-speaking Canadians made special efforts to upgrade living standards and to achieve language rights in schools, law courts and other official institutions. Examine figures 21.21, 21.22 and 21.23. What do these three maps indicate about the importance of French language and culture in Quebec? One manifestation of this has been the emergence of a separatist movement. On a visit to Canada in 1967, Charles de Gaulle, President of France, was rebuked by the Canadian government for publicly supporting the idea that Quebec should become independent of the rest of Canada.

In 1963 the Canadian government established the Royal Commission on Bilingualism and Biculturalism. In its first report issued in 1968, among other recommendations it suggested that a province should declare itself bilingual if its official-language minority exceeded 10 per cent of the population. Examine figure 21.24. Which provinces of Canada would thus declare themselves bilingual? It was also suggested that bilingual districts should be established on this basis. Other recommendations concerned the rights of French-speaking Canadians in schools, law-courts, parliament and government. One implication of the Royal Commission's recommendations was that French-speaking Canadians would be freer to choose where they would live and work throughout the country; the nation's cultural diversity would thus be heightened.

It was in the province of Quebec that most concern was felt about the position of French Canadians in the country's social and economic structure; two of the main problems were their lower standard of living and generally lower social status. Montreal, as the largest French-speaking city in the world after Paris, was one major centre of concern. In study 16 you examined Montreal's manufacturing structure and distribution, and learnt a little about the distribution of population and incomes.

Examine figures 21.25 and 21.26. They show distributions of language and ethnic origin in Montreal. Make a sketch map showing where the French language and French ethnic origin and where the British language and British ethnic origin are predominant. How does the information on your sketch map relate to the distribution of manufacturing in Montreal in study 16? Which of the two groups are concentrated in areas where manufacturing is concentrated? What does this indicate about the relative standard of living and social status of the two groups?

Figures 21.27, 21.28, 16.10, 16.11 and 16.12 all give further detail about the types of areas in which each of the two groups live. Do you think there is evidence here to support allegations that French-speaking people have a lower social and economic status?

Canada has tried to encourage cultural diversity and forestall injustice to minority groups by declaring a bilingual and bicultural policy. Would this kind of policy solve any economic differences that may exist? Might such a policy be successful in Fiji?

22

What affects your health?

Before you read further in this section, stop and list the factors that influence your health at any particular time, namely what causes you to feel well (or ill, as the case may be) *now*.

It is quite easy to list a number of factors (they could be called *inputs* into the health system), but did you wonder what really is meant by the term 'health' or a 'healthy person'? The World Health Organisation in 1965 defined health as 'a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity'. This means that the inputs into the health system could range widely. Consider the following classification of inputs:

- Food
- Conditions for work
- Availability of recreational opportunities
- General physical environment
- General social environment.

Did your list of factors influencing health include all these aspects? Are there any others you could add?

To be truly healthy, a person should enjoy a balanced relationship of body and mind and complete adjustment to the environment. In contrast, sick or diseased persons represent maladjustment or maladaptation to an environment.

Now reread the above paragraph; is there a flaw in this statement? Are you prepared to argue that, instead of the environment shaping man's being, man now shapes his environment? Of the changes man has brought about in his environment, some, such as improved housing, water supply and sanitation, have been beneficial; some, such as atmospheric and water pollution and excessive noise, are obviously harmful; still others, such as nuclear explosions, might well prove catastrophic. Surely then any reference to 'environment' must have linked to it the idea that it is changing, or dynamic.

This dynamic context is well illustrated by the way in which human life expectancy over the years reflects environmental change. Study figure 22.1.

What has been the expectancy increase in years, for males and females, from 1901 to 1971? What

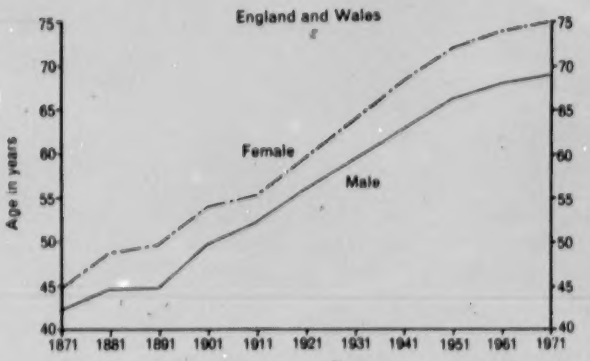


Figure 22.1: Expectation of life (in years) at birth, England and Wales, 1871–1971

do you think are the main causes for this increase?

Can you suggest any reasons for the expectancy difference between the sexes? Might this difference be linked with the fact that England and Wales are highly industrialised? If so, to what extent?

From 1871 to 1971, expectancy increased for both males and females. But have life-spans lengthened at an even rate over the whole period? Did the rate of increase fall off at particular stages? When? What reasons can you give for this?

What do you think are the major causes of early mortality in an industrialised society?

The communication of cholera: a case study

The following extract will give you some idea how the *distribution* in *spatial terms* of a disease can give clues to its origin. As you read this extract, jot down other diseases you can think of where an analysis of the distribution of outbreak could help in controlling the spread of the disease.

The method of map comparisons has played an important part in the study of the ecology of human disease. By plotting the distribution of cases of a disease valuable clues have been gained on the environmental factors that favour its spread. Perhaps the most famous example was John Snow's nineteenth century inquiry into the mode of communication of cholera. Cholera is an acute infectious disease characterised by violent purging, loss of fluid,

muscular cramps, and rapid collapse. Although known in India since early history it did not reach Europe until the early nineteenth century when a series of epidemics caused high death rates in the unsanitary conditions of English mining and industrial towns.

Although at that time a few medical men were beginning to suspect that micro-organisms might be the cause of infectious disease, the science of bacteriology had scarcely begun and the most popular explanation was the 'miasma' theory. It was assumed that soil polluted with excrement and refuse of any kind gave off 'atmospheric miasma', or noxious exhalations, which were breathed in by the victim and absorbed into the bloodstream. Since the worst outbreaks of disease of all kinds were in the low lying seaport and industrial areas where sanitary conditions were often appalling, the miasma theory was at least plausible when the bacterial cause of disease was unknown. By 1848 a London doctor, John Snow, became convinced that since the first symptoms of cholera patients were always in the alimentary canal, the 'poison' must be taken directly into the canal by mouth and not by the inhalation of 'effluvium'. Snow suspected that drinking water, contaminated with sewage from the excreta of cholera patients, was the principal source of communication of the disease.

It was a revolutionary view at the time, but in August and September 1854 Snow was able to put his theory to a terrible test when the worst and most localised outbreak of the disease ever to occur in England took place in a few streets in the West End of London. In this densely populated area, drinking water was supplied by pumps from shallow wells in the gravels which overlay impervious clays at no great depth. Cesspools, drains, and poorly laid sewers would have provided ample opportunity for contamination of water supplies. In the course of 10 days there were some 600 fatal attacks of cholera within 250 yards of the common water supply pump in Broad Street. The mortality would undoubtedly have been greater but for the flight of three-quarters of the population, most of them tailors and their families, who worked for clothing shops in nearby fashionable Regent Street.

Snow focused attention on the Broad Street pump by locating on a large scale map the house where each victim became ill. He plotted the position of all the water pumps in the district to which the public had access at the time, and noted that the number of cases diminished away from the Broad Street pump. Nine days after the outbreak of the epidemic Snow was convinced that the Broad Street pump was the offending source. He was able to persuade the authorities to remove the handle and the outbreak rapidly subsided.

Snow's map correlation was all the more striking when some apparent exceptions were investigated. Although there were several fatal cases near the pump in Great Marlborough Street the water there was so obviously impure that many people avoided it and preferred to travel the longer distance to Broad Street. Although there were several deaths near the pump in the lower right of [figure 22.2] the configuration of the streets and alleys made it easier to reach the Broad Street pump, and from personal inquiry Snow was able to show that most of the more distant victims had used the Broad Street pump. A workhouse with 535 inmates, living in conditions of gross overcrowding, had only five deaths. As the workhouse had its own well and a piped supply from the Thames River, no water was carried from the Broad Street pump.

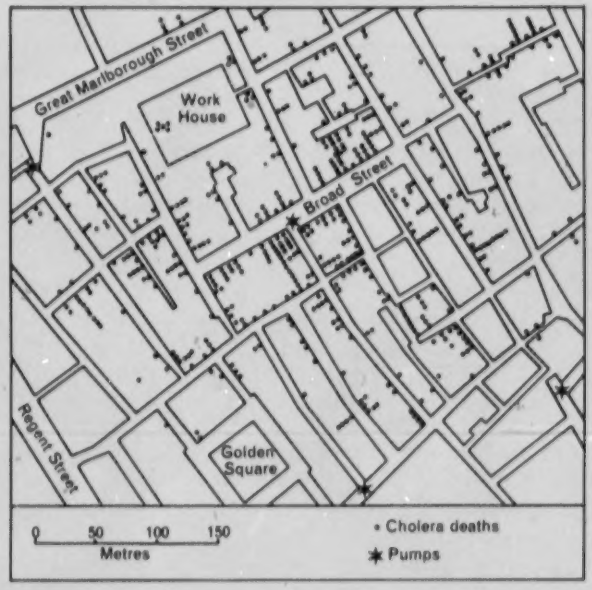


Figure 22.2: Redrawing of John Snow's map of the distribution of cholera deaths in a portion of the West End of London, 1854

In another outbreak of cholera in South London in 1854 Snow was able to show by map and statistical evidence that deaths were confined almost entirely to those houses served by the pipes of a water company that took its supply from the polluted River Thames at Westminster. A rival water supply company had recently changed its intake to a purer source further upstream and the houses supplied by this company had a much lower death rate from cholera.

Although John Snow's theory was received with scepticism by the medical world, far-reaching sanitary reforms were carried out over the next decade in British cities. Care was taken to ensure that water supplies were free from contamination from human sewage and there were no epidemics of cholera in Britain after 1866.

Some thirty years after Snow's book was published, and long after his death, Robert Koch discovered the micro-organism *Vibrio cholerae* which caused the disease. To geographers the great interest of John Snow's work is that he used the method of comparing geographical distributions in testing a theory on the way a disease spreads from person to person, even though the ultimate cause of the disease was as yet unknown.

M. McCaskill, *Patterns on the Land*
(Melbourne: Longman, 1973)

Now try some medical research for yourself! In examining the data provided, however, remember that you are only dealing with simple interrelationships, and nowadays in a very dynamic environment the number of significant variables to be found in an industrialised society is enormous. Nevertheless Dr Snow, as you have just read, succeeded in identifying an interrelationship of great consequence! Try also to be as precise as possible. For example, if you can identify a link between coal mining and bronchitis, name the counties, and if possible the cities, where this correlation seems most apparent (refer to figure 22.3).

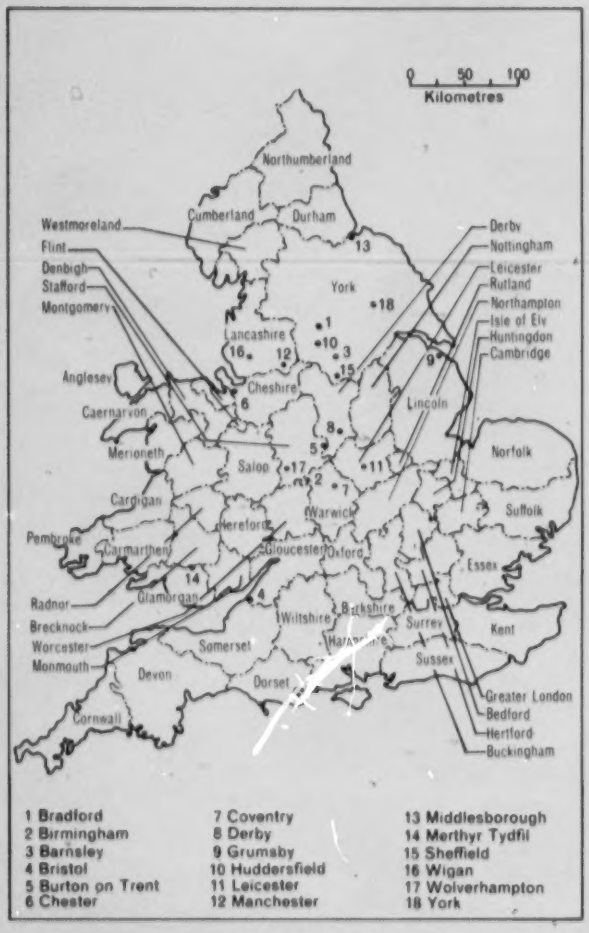


Figure 22.3: England and Wales—administrative divisions

Are there any correlations apparent between the elements of each of the following pairs? If so, suggest reasons why this should be so.

- Population density (figure 22.4) and infant mortality (figure 22.5)
- Infant mortality (figure 22.5) and coal mining (figure 22.6)
- Infant mortality (figure 22.5) and annual income (figure 22.7)
- Bronchitis (figure 22.8) and coal mining (figure 22.6)
- Bronchitis (figure 22.8) and infant mortality (figure 22.5)
- Population density (figure 22.4) and bronchitis (figure 22.8)
- Population density (figure 22.4) and annual income (figure 22.7)
- Coal mining (figure 22.6) and annual income (figure 22.7)
- Bronchitis (figure 22.8) and annual income (figure 22.7)

FURTHER ACTIVITIES

Make a survey of the students in your class and draw a diagram to show the possible interrelationships between distance travelled to school and the number of common colds suffered over the last twelve months. (For the technique of drawing a scattergram, see Level One, *Man and Space*, page 98.)

If practicable, try to subdivide your scattergram into four different sections:
(i) Those travelling by public transport
(ii) Those travelling by private car
(iii) Those travelling by bicycle
(iv) Those travelling on foot.
What conclusions, if any, can you draw from your research?

Show by means of bar graphs any interrelationships that may become apparent between the number of common colds in the previous twelve months and:
(i) Houses with complete central heating systems
(ii) Houses with partial systems (e.g. space heating units)
(iii) Houses with individual units (e.g. gas or electric fires).

Carefully study figures 22.9 and 22.10. State, precisely, three deductions that can be made from the information presented.

Record the information in table 22.1 in the form of a line graph. The death rate should be the vertical axis. What two deductions can be drawn from this graph?

Table 22.1

Years since smoking was stopped	Lung cancer death rate (%)
0	1·7
2	0·63
6	0·42
15	0·2
25	0·2
Non-smoker	0·1

Source: Based on Doll and Hill, *British Medical Journal*, 1964

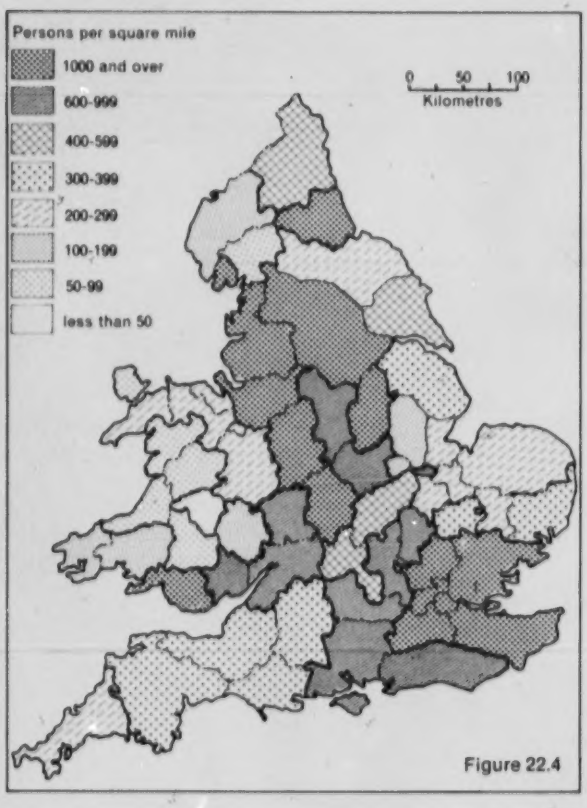


Figure 22.4

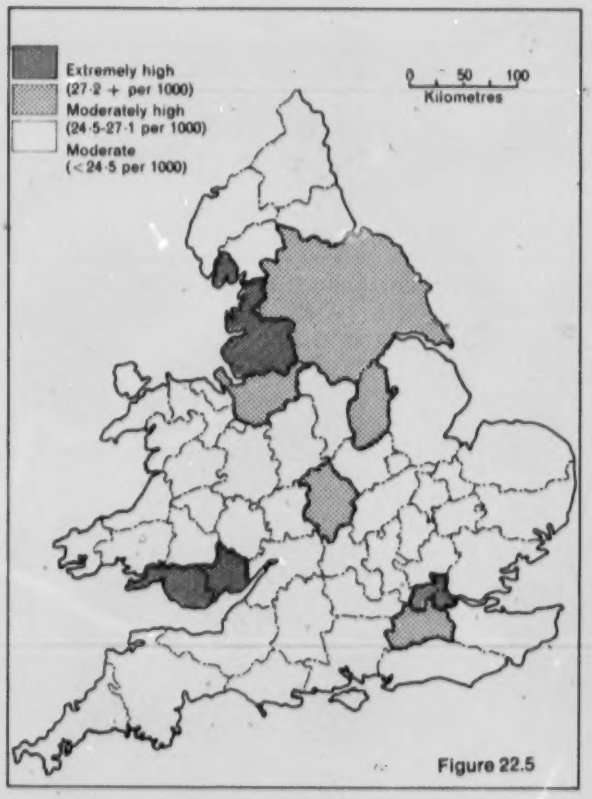


Figure 22.5

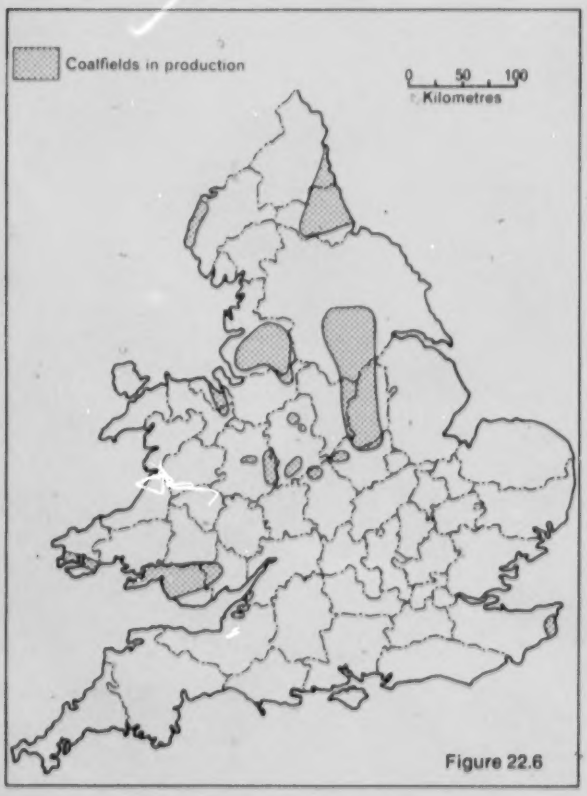


Figure 22.6

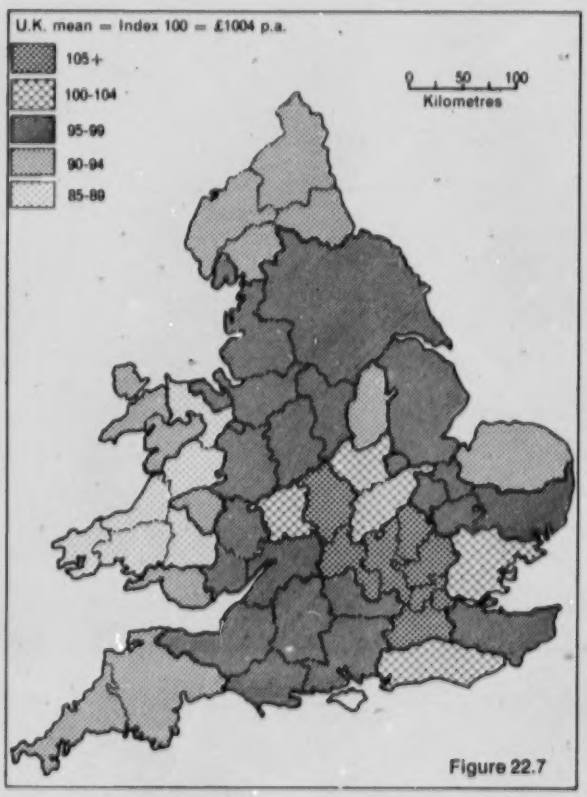


Figure 22.7

Figure 22.4: England and Wales—population distribution, 1961

*Figure 22.5: England and Wales—infant mortality per 1000 live births (simplified from Howe, **Man, Environment and Disease**, 1972)*

Figure 22.6: England and Wales—distribution of producing coalfields

*Figure 22.7: England and Wales—income distribution, 1964–65 (simplified from Rawstron and Coates, **Regional Variations in Britain**, 1971)*

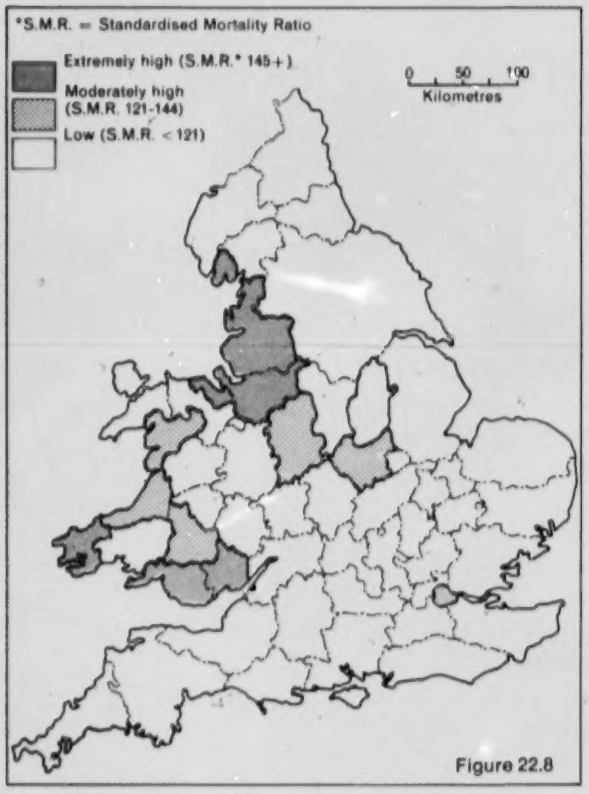


*Figure 22.8: England and Wales—male mortalities resulting from chronic bronchitis, 1959–63 (simplified from Howe, **Man, Environment and Disease**, 1972)*

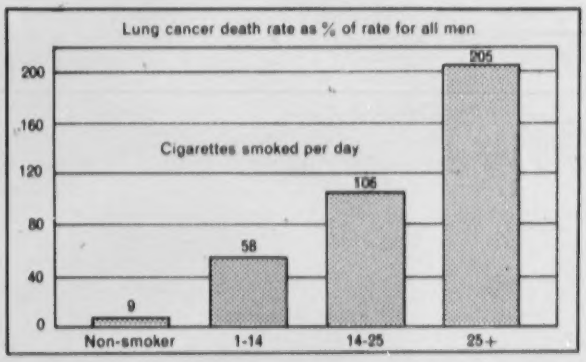


*Figure 22.9: Male death rate according to the number of cigarettes smoked per day (after Doll and Hill, **British Medical Journal**, 1956)*

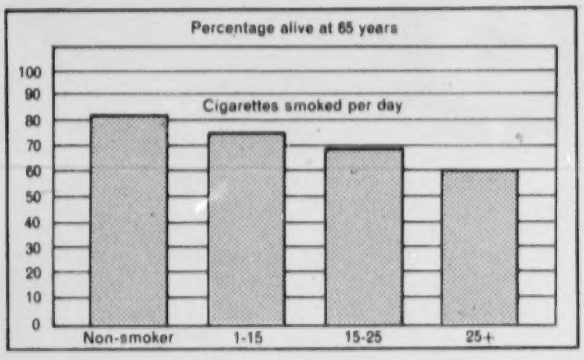


Figure 22.10: Percentage of 35-year-old male cigarette smokers who live to age 65 years (Royal College of Physicians, London, 1971)

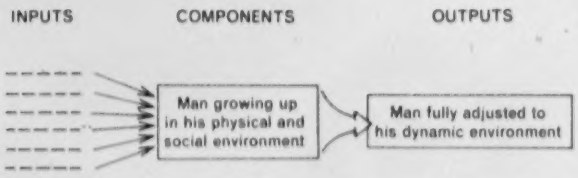


Figure 22.11

What generalisation, if any, are you prepared to make after working with this information on cigarette smoking?

Expand and complete figure 22.11 in your own workbooks to illustrate the health system.

People's health obviously depends on a wide range of factors or inputs. To what extent, then, can or should society restrict those activities of men which adversely affect our health? You will probably answer that society must restrict such activities—but can it? Are you prepared to pay for the research or modifications necessary to reduce various forms of pollution? Are you prepared to ask, or force, governments to ban nuclear weapons? Can society afford economically or politically to ban those things that damage our health? Conduct a classroom debate on this question.

23

The drainage basin

It is a reasonably obvious fact that, since all life on earth—human life especially—depends in some way on water, there are a number of features of drainage basins that affect our everyday existence. Look at figures 23.1 and 23.2, showing a model drainage basin.

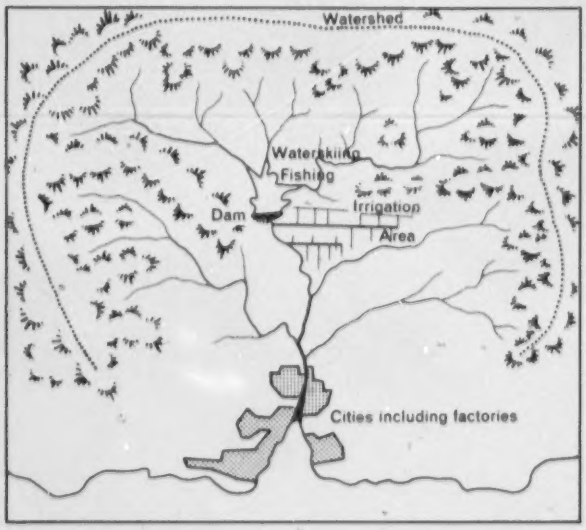


Figure 23.1: Map of a model drainage basin

Make a list of all the features of drainage basins that affect our lives. Some of the features are shown in the two diagrams: others you should be able to work out for yourself. Thus a drainage system can be represented as in figure 23.3.

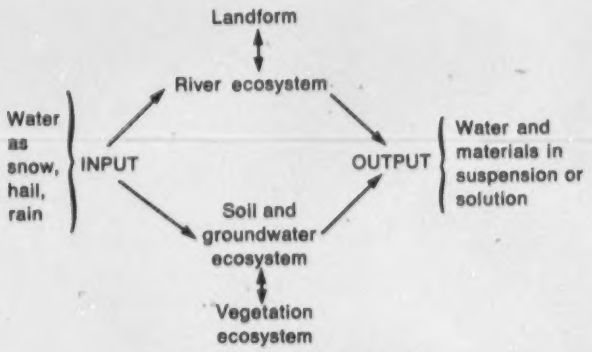


Figure 23.3: The drainage system

Problems of precipitation

How often have you seen newspaper photographs and articles like those in figures 23.4 and 23.5? Floods, or droughts, are reasonably common occurrences in the lives of those who inhabit drainage basins. In figure 23.4, two paragraphs

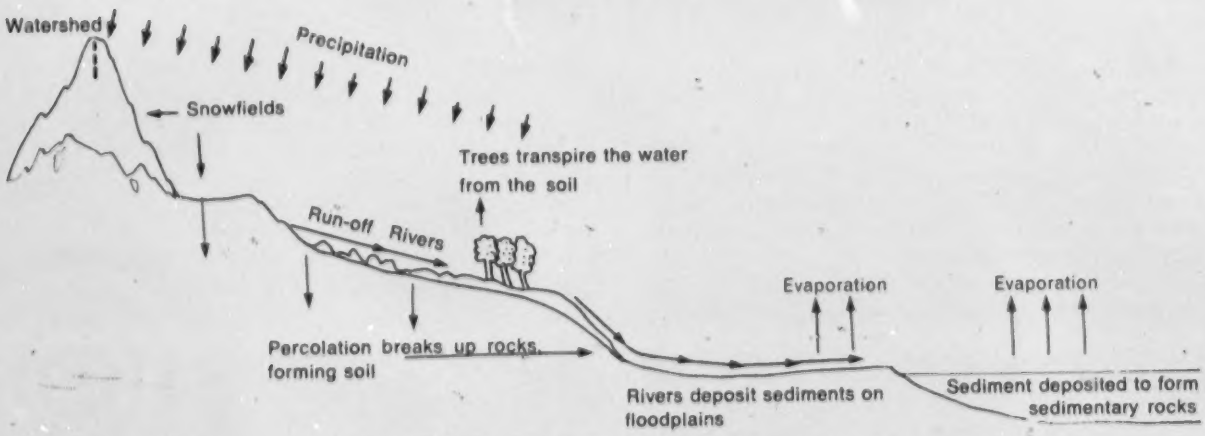


Figure 23.2: Cross-section of model drainage basin

Albury awash again—rescue crews kept busy

From NOEL MAUD

ALBURY.—Water up to two feet deep flowed through hundreds of Albury homes yesterday, as the city was awash for the second time in a week.

Industries and stores were closed as the flash flood swept through them.

At the height of the flood a man died in a water-isolated butcher's shop.

His name is not known. He is believed to have had a heart attack.

Mrs. Jessamine Lavis, 85, is carried from her flooded home in Jones Street, where more than 20 homes were flooded.

Every road out of Albury was cut except for the Hume Highway, which has been lightly flooded in places.

Stranded travellers have booked out all accommodation.

The Albury-Border Rescue Club carried Mrs. Jessamine Lavis, 85, from her home in Jones Street on a stretcher.

More than 20 homes in the street, near the centre of the city, were flooded.

There were many accidents in the wet and Albury Hospital staff were kept busy treating victims.

The flooding was caused by 3½ in. of rain which fell on surrounding hills, already sodden from 4 in. of rain a week ago.

Water ran off the hills into the valley in which Albury lies and joined the city's overtaxed storm water system.

The flooding is worse than last week's, which was described as the worst in the city's history.

The flood hit quickly. Streets, dry at 3 p.m., were awash half an hour later.

It hit hardest in North and South Albury, both rapidly expanding industrial and residential suburbs.

The Southern Mill plant which sustained $4000 damage in last week's flood, was hit again.

Albury's largest club, the Lavington Sports Club, was isolated for several hours.

Figure 23.4: ***Age****, 11 January 1974*

WITH BABY, pram and basket in arms, a couple wade calf-deep down flooded Maitland Street, the main street of Narrabri, in north-western NSW, to do their shopping yesterday. Earlier this week only graders, tractors and horses could traverse the muddy waters.

Figure 23.5: ***Australian,*** *11 January 1974*

indicate how the Albury flash flood occurred. Heavy rainfall on the surrounding hills one week prior to the flood had filled the drainage features (refer back to the model in figures 23.1 and 23.2), and the additional rainfall (almost as heavy) on the same hills was funnelled into the valley, or the basin, where Albury is located, causing water to flow 60 centimetres deep in parts of the city. The flooding at Narrabri was caused by more widespread rain, but basically the same system operated: the drainage lines—rivers and creeks—had to carry too much water so they overflowed.

Perhaps another question we might first consider is why rivers have water in them even when there has been no rain. Obviously, the water that flows in rivers comes from rainfall or, in some cases, from melting snow. Why, then, do rivers keep flowing weeks after rain has fallen or the snow has melted completely?

What happens to rainfall when it hits the ground? Probably most of it will just soak or *percolate* into the ground, especially if the land is reasonably flat. If the land is steep, it is more likely that water will run across the top of the ground—a process referred to as *run-off*. Find a piece of ground that has flat areas and uneven sections with slopes of varying steepness. Experiment until you find out how steep the slope has to be before most of the water will run off rather than percolate.

Why does water percolate into the ground? First, of course, the ground should be called *soil*, that material found between the underlying impervious rock and the surface of the earth. Why does water enter the soil? Perhaps you might have answered: 'Because soil is soft, and not hard and solid like rock.' What does this mean? Soil is 'soft' because there are spaces between the soil particles. When the soil is dry the spaces are filled with air; when water hits the soil, it finds these spaces and infiltrates them. (Read the description of soil in study 24.)

What has this got to do with rivers? When rain is falling and water is infiltrating the soil, the spaces in the soil fill up with water. If the rain is heavy enough and prolonged enough, all the spaces may be filled up. Subsequent rainfall cannot infiltrate and must run off.

Figure 23.6 illustrates what happens. On the left-hand side of the diagram the rainfall infiltrates the soil and, below a certain level called the *water*

table, permanently saturates it. Water tends to seep towards the river through this saturated zone. On the right-hand side of the diagram the rainfall has filled up all the spaces with water and so *run-off* is occurring. On this side, the river is receiving water from seepage through the soil and from run-off across the surface.

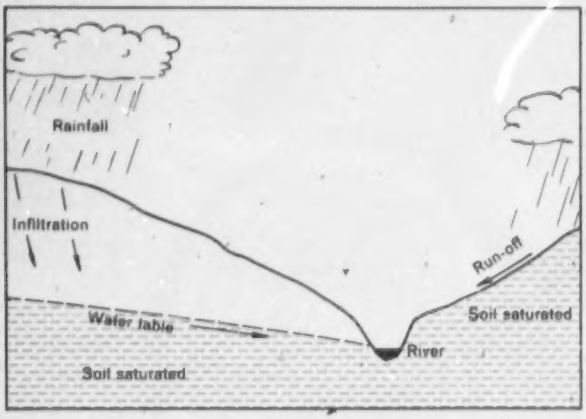


Figure 23.6

You might try an experiment to illustrate this. If you have a large block of foam-rubber sponge you could imagine it to be soil—it has spaces in it, and water will infiltrate it. On the surface of the sponge, cut slopes and a channel as in the cross-sectional diagram, figure 23.6. Sprinkle water on the sponge and observe what happens. (If you can enclose the sponge snugly in a glass-sided container, you can see the water action more clearly.) You might also experiment in this way, using a deep bed of dry sand in an aquarium, to see how water acts on and in soil.

Why, then, do rivers have water in them, even after there has been no rain for some time?

With all these ideas in mind, do you now have any ideas why floods occur? Let's look at this question another way.

The problem in eastern Victoria

In January and February 1971, very bad floods hit the Macalister River area of Gippsland, in eastern Victoria (see figure 23.7). Buildings and bridges were washed away, sheep and cattle were isolated or drowned; the cost of the damage was about $1.6 million. When farmers and local councils are given advance warning of such floods, they can take measures to reduce their impact. The organisations involved in giving early warning of floods are the State Rivers and Water Supply Commission (S.R.W.S.C.) and the Bureau of Meteorology.

When water is flowing in a channel it only rarely fills it completely (figure 23.8). When a large amount of water is trying to move down the valley, the channel may fill up completely. This is called *bankfull* stage (figure 23.9). If still more water comes down, the river may 'break its banks' and flow outside the channel (figure 23.10). How can the S.R.W.S.C. engineers and the Bureau of Meteorology weather forecasters predict when this is going to happen?

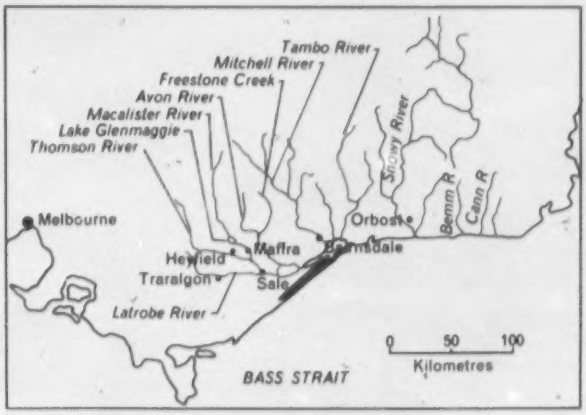


Figure 23.7: Rivers of eastern Victoria

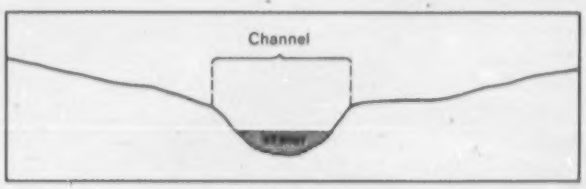


Figure 23.8

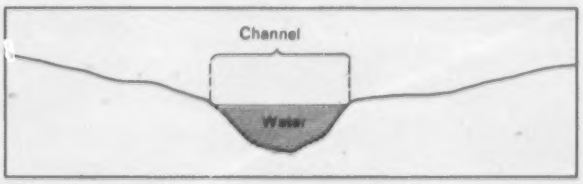


Figure 23.9

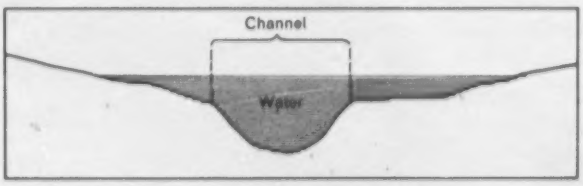


Figure 23.10

In the area of eastern Victoria where those floods occurred, there are a number of rivers. What do rivers do? The answer appears simple: 'They carry water.' But does this describe their total function? Rivers actually do much more; they have a marked effect on all parts of the earth's surface where rain falls, by draining flowing water from the areas

that have received the rainfall. Imagine you have a large sheet of metal and you bend it so that it curves as in figure 23.11.

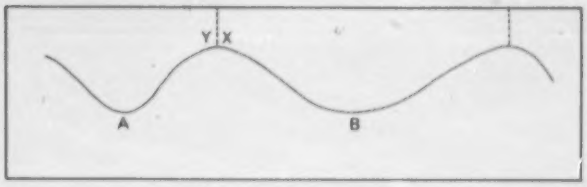


Figure 23.11

If you sprinkled water over the sheet of metal, what would happen? Obviously the water would form two rivers, A and B. Into which of these rivers would a drop of water falling at point X run? What about a drop of water falling at point Y? Somewhere between X and Y the direction of flow changes; this is the highest point between the two rivers. On the diagram, these highest points are indicated by dotted lines; between these lines is the area drained by river B. In cross-section, this resembles the side view of a basin, hence the name *drainage basin*. However, three-dimensionally it is not quite a true basin: most drainage basins have an outlet in one side where the water flows through to the next river in the system or to the sea, as you saw in figure 23.1.

What is the name given to the ridge, shown by the dotted line, that separates one basin from another? If you studied figure 23.1 carefully you should know.

Figure 23.12 shows the area classified by the S.R.W.S.C. as Basin 25 of Drainage Division 2 (see inset), in which there are three major rivers—the Avon, Thomson and Macalister. Within this area there are a number of smaller drainage basins, one for each river. These are marked on the map. Which major river's drainage basin is the largest? What effect do you think the size of the basin would have on the amount of water flowing in the river?

To forecast floods, the S.R.W.S.C. and the Bureau of Meteorology first of all need to know how much rain is falling in the basin or *catchment*. Rainfall observers in the catchment area read the amount of water collected in rain gauges.

Then the S.R.W.S.C. engineers have to estimate the 'wetness' of the river catchment (the amount of water in the soil), and calculate how much more rain would produce run-off.

By examining weather forecasts and developments, and measuring river heights and the flow rate of water in the river, they can then attempt to predict the degree and timing of flooding at selected locations along the river.

Table 23.1: Gippsland floods in January and February 1971
Daily mean flows in cusecs*

		GAUGING STATIONS										
		Macalister River at			Thomson River at			Aberfeldy River at	Avon River at	Freestone Creek at	Valencia Creek at	Glenmaggie Creek at
		Glenmaggie†	Stringybark Creek	Licola	Coopers Creek	The Narrows	Aberfeldy	Beardmores	Buxtons	Briagolong	Radettis	Seaton
January	27	62	131	96	188	133	72	22	31	46	11	75
	28	57	104	84	154	101	95	17	30	45	10	60
	29	453	108	86	281	115	90	26	441	1 606	555	1 685
	30	23 360	8 895	3 502	4 804	787	207	4 028	20 798	13 980	8 558	7 390
	31	15 840	5 200	1 946	5 187	757	178	3 725	6 264	2 192	1 514	2 913
February	1	6 280	2 668	1 307	3 084	527	151	1 951	4 037	963	729	1 087
	2	3 018	1 619	888	1 607	366	147	913	2 370	671	379	281
	3	2 988	1 013	627	953	251	114	542	1 280	469	224	118
	4	2 928	790	452	715	233	94	385	614	326	149	83
Instantaneous peak‡ (cusecs)		45 020	11 840	5 090	6 430	980	280	5 480	37 650	21 200	14 000	16 150
Date		30	30	30	31	30	30	31	30	30	30	30
Catchment area (square miles)		730	607	476	350	200	128	120	224	120	86	55
Peak run-off§ (cusecs/ square mile)		61	20	11	18	5	2	46	168	177	163	294

*1 cusec = 1 cu. ft/sec = 0·0283 $m^3 s^{-1}$

†Not natural flows; outflow regulated with gates

‡Instantaneous peak for Lower Avon River at Stratford was 70 000 cusecs (estimated)

§Figures rounded off

Automatic water level recorder was washed away. Discharges estimated.

Why, then, do floods occur with little warning to the public? Can you think of any situations in which the engineers might not be able to predict floods? What happened in January 1971 to cause such a devastating and costly flood with little advance notice?

This is the problem that is causing concern to the Bureau of Meteorology, the S.R.W.S.C., local farmers and civil defence authorities.

Examine table 23.1, which shows, for selected points on the rivers, the daily mean flow in cusecs (1 cusec = 1 cu. ft /sec = 0·0283 m^3 s^{-1}). The eleven gauging stations in table 23.1 are indicated in figure 23.12.

Make a tracing of figure 23.12, marking in the rivers and the gauging stations. Using graph paper, make line graphs of the daily mean flow for each gauging station and stick them as close as possible to the gauging station. (Figure 23.13 indicates the type of graph you should draw.) Also mark on the map the instantaneous peak. (Note the estimated instantaneous peak for the Lower Avon River at Stratford.)

Which rivers appeared to provide most water for the flood? All rivers rose (as indicated by increase in daily flow), but some rose more than others. On several rivers there is more than one gauging station. By comparing the degree of rise at these stations, try to find the location of the very heavy rainfall that caused the flood.

So far you have been looking at absolute amounts of water, but these only assist to a limited

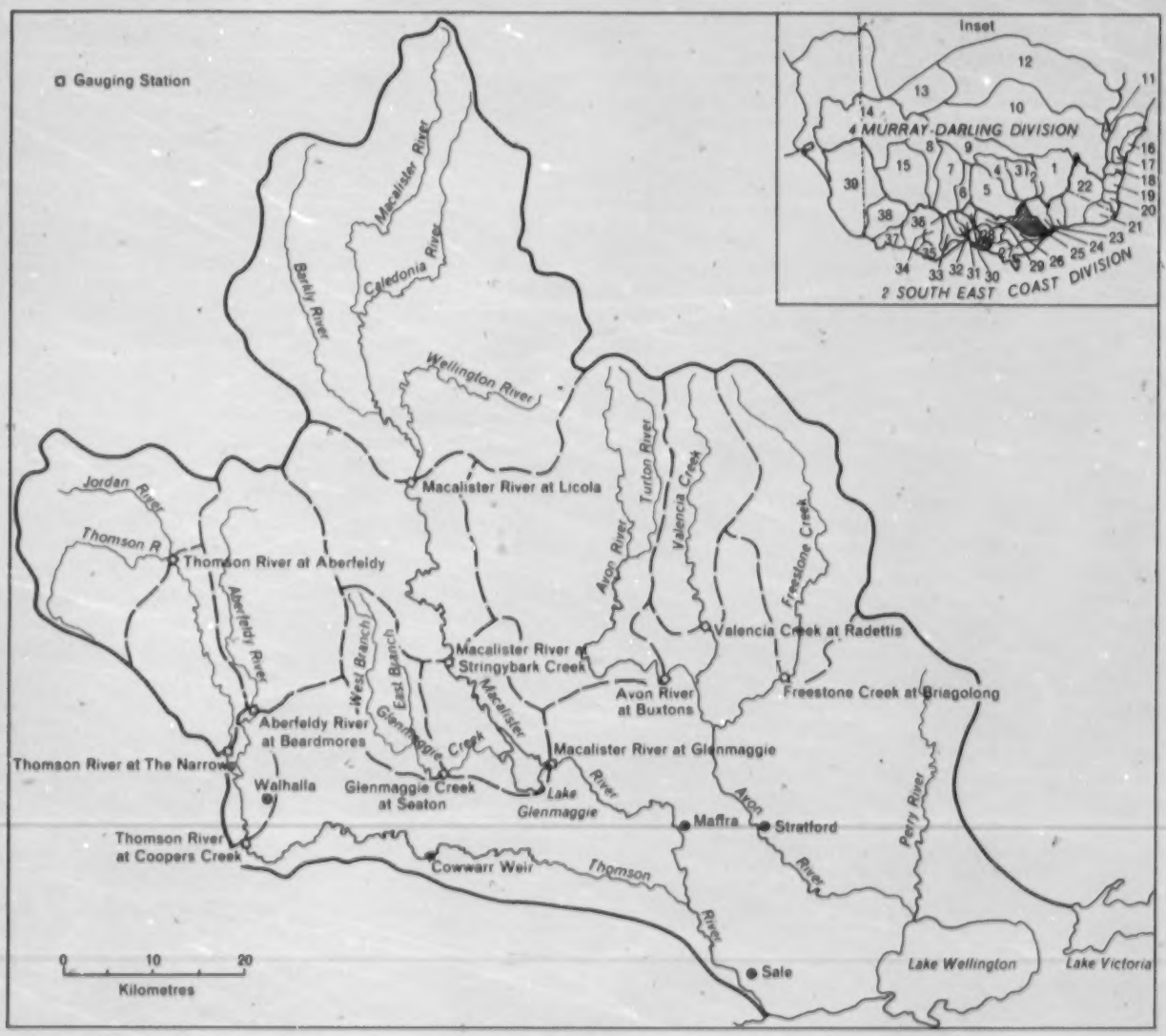


Figure 23.12: Drainage Division 2, Basin 25

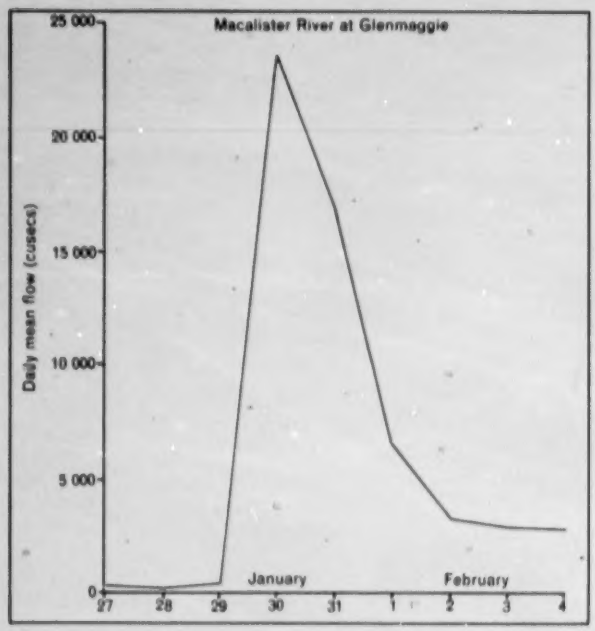


Figure 23.13: Sample gauging-station graph

extent in predicting floods. Examine the statistics for the Macalister River at Glenmaggie. The gauging station there registered the highest daily flow, but this would be expected. Why? Look at figure 23.12 and try to explain why. It was estimated that Stratford on the Avon River had the highest instantaneous peak. Again, this would be expected. What aspect of drainage basins would lead to this conclusion?

At the bottom of table 23.1 are details of peak run-off in cusecs per square mile for each drainage basin shown in figure 23.12. Which basins had the highest run-off on this basis? What would this indicate about the rainfall within each basin? So whereabouts in this area was rainfall the heaviest?

Were you right? Figure 23.14 shows the actual rainfall at this time. The rainfall is concentrated in very small areas, and if you compare the areas of heavy rainfall with the map of drainage basins you should be able to explain the very high run-off that you noted previously.

Although figure 23.14 shows that the very heavy rain occurred after 6 p.m. on Friday, 29 January, the existing radio telemetry system showed enough rainfall and run-off for the District Engineer at the Maffra office of the S.R.W.S.C. to issue flood warnings for the Macalister River at 4.50 p.m. The radio telemetry system on the Macalister consists of a base station at Glenmaggie Dam and four remote-controlled stations, those at Licola and Stringybark Creek indicating water level, and those at Connors Plain and Porters Creek indicating rainfall. The staff can contact these stations for instantaneous readings.

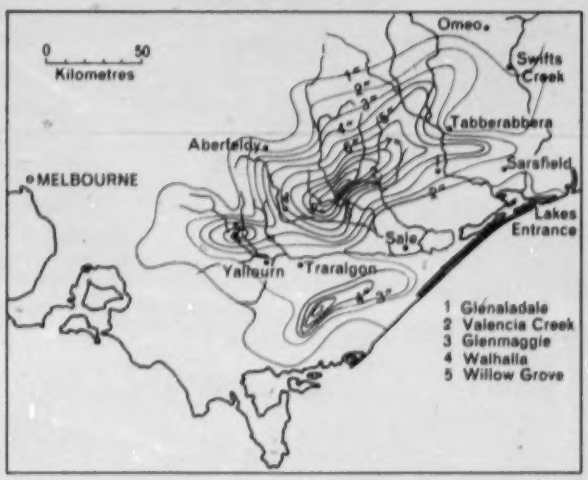


Figure 23.14: Rainfall isohyets (inches), 6 p.m. 29-1-71—6 a.m. 30-1-71

The Maffra office issued its warning for the Thomson River at 4.30 p.m. on 29 January, but this was based on actual observations at the Cowwarr Weir (see figure 23.12). The Coopers Creek gauging station did not show greatly increased river flow compared with what the officers observed at the Cowwarr Weir. What must have happened between these two points? What evidence does figure 23.14 provide?

On the Avon River and Valencia and Freestone Creeks, all gauging stations were washed away, as table 23.1 shows. There was also no flood warning system similar to the Macalister River network.

What problems did the officers of the S.R.W.S.C. and the Bureau of Meteorology have in predicting these floods? What do you think could be done to improve the warning system?

What caused this heavy rainfall? Below are extracts from the Bureau of Meteorology's review of the synoptic situation and rainfall in Victoria during this week. Read these in conjunction with figure 23.15. What is the answer to the question?

Synoptic situation

A north-east to northerly airflow on the 24th and 25th brought high temperatures to most districts. A trough of low pressure formed over South Australia on the 24th and on the 25th moved to the Victorian border, where it remained stationary until the 27th, due to a blocking high-pressure system over New Zealand. This low-pressure trough covered eastern Victoria on the 28th between the blocking anticyclone and another large anticyclone to the south of the Great Australian Bight. Strong, cool south-easterly winds developed as the anticyclone moved south-east, cutting off the depression, which remained almost stationary over Victoria until the end of the month, bringing widespread rain. This rain was caused by a pool of cold air in the upper levels of the atmosphere interacting with moist, warm air in the lower layers.

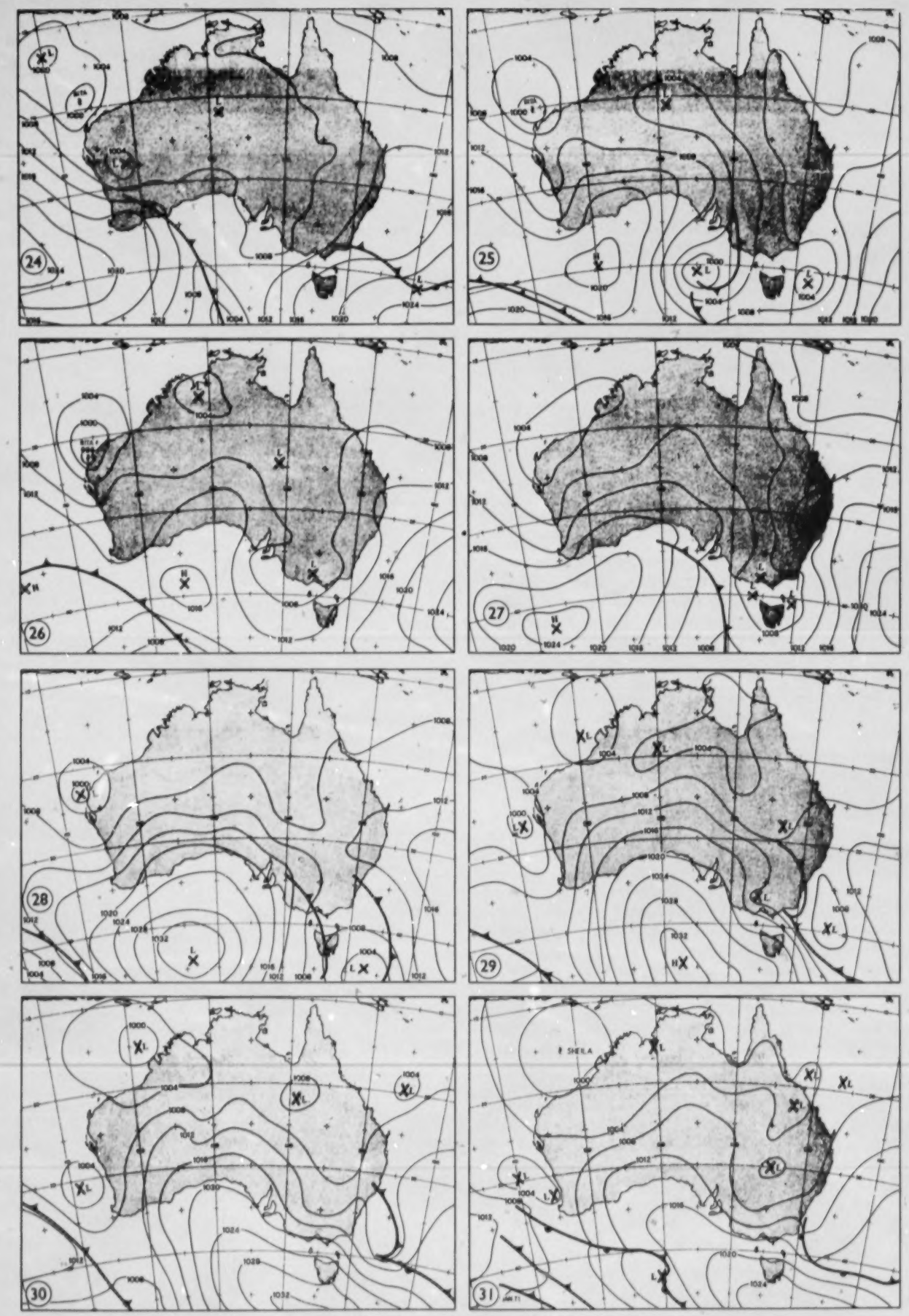


Figure 23.15: Daily synoptic charts, 24–31 January 1971 (pressure in millibars)

Rainfall

From the 24th to the 27th all districts except the Mallee reported variable falls from showers and thunderstorms. General rain fell in the southern half of Victoria for the 24-hour period ended 9 a.m. on the 29th, with Weeaproinah recording its maximum 24-hour rainfall total for January of 456 points.

Exceptionally heavy rain fell in Gippsland during the next 24 hours with 7.28 inches being recorded at Connewarre, 6.81 inches at Glenmaggie and 6.55 inches at Willow Grove. In Gippsland, Walhalla (12.62 inches), Valencia Creek (11.58 inches), Glenmaggie (11.04 inches), and many other places have had their wettest January on record. Weeaproinah (11.95 inches) and the west coast have had their wettest January, while Forrest (4.60 inches) and Gellibrand River (5.68 inches) have had their wettest January since 1937. . . .

January rainfall was generally above average in all districts except the Mallee and Wimmera, where it was up to 40% below. East Gippsland received more than twice its average.

Bureau of Meteorology, *Monthly Weather Review, Victoria: January 1971*, pp. 2 and 3

As you saw in study 7, the local authorities and farmers take precautions against floods, but obviously more could be done if warnings were given earlier. The S.R.W.S.C. wants a full radio telemetry system. What does the Bureau of Meteorology think about the problem? Read these extracts from the Bureau's annual report for 1970–71:

The task

Floods occur in all Australian streams. However, the frequency, duration and pattern of flooding vary greatly, as does the economic and social impact of flooding on the community. In parts of northern Australia floods recur rather regularly with the 'wet' season: in southern Australia, flooding is irregular.

Although flood rains have some long-term benefits they endanger life and threaten loss of property. Flood warning services aim to minimise losses and avert death and injury.

The type of warning service that can be effective in a particular river valley depends on the pattern, frequency, severity and rapidity of flooding in the valley; the population and economic development; the use of the floodplain and the availability of catchment rain and river data. The Bureau aims to provide forecasts of flood heights expected at key localities on a stream (Locality Warning Service) as well as generalised warnings of the flood expected within broad zones of a river valley (Valley Warning Service).

A flood warning system includes:

- observation of rainfall and river heights at a network of observing stations
- analysis of this information at a flood forecasting centre
- daily assessment of flood risk by estimating the 'wetness' of the river catchment (the amount of moisture stored in the soil) and calculating the rain that would produce flood run-off at this level of 'wetness'
- a continuous watch on the possibility that this amount of rain could fall
- preliminary flood warnings when flood-producing rain is forecast
- alerts of significant rainfall occurring unexpectedly, or of rainfall which develops more quickly or heavily than anticipated
- prediction of the degree of timing of flooding at selected locations along the river
- flood warnings to the public
- interpretation of flood warnings in terms of the expected geographical areas and depths of flooding, and
- warning advices to residents in flood-threatened areas.

In long rivers with flat gradients where floods generate and move slowly, adequate warning is frequently possible from reports of rising river height. However, most of the rivers which flow to the sea from the Great Dividing Range across the coastal plain flood rapidly. These threaten many towns and highly developed areas on the eastern coastal fringe. Warnings based only on the observed rise of these streams come too late, so flooding must be predicted from observations and forecasts of rain.

To forecast rainfall for a given river valley it is necessary to collect and analyse information for the whole of the continent or even the hemisphere.

Developing a fully effective flood warning system demands observations of, and research into, the atmosphere and hydrological processes over the continent and the hemisphere, and also on the river valley scale. . . .

Applying flood forecasts

Operating an effective flood warning service requires:

- a network of rainfall and river observing stations
- a flood forecasting centre organised to operate around the clock at short notice
- rapid, secure communications between observing points, the flood forecasting centre and threatened areas
- collaboration between weather forecasting centres and flood forecasting centres, and valley authorities (including state or local government bodies) responsible for relief and rescue operations, etc.
- prior development of techniques for forecasting flood behaviour.

The Bureau of Meteorology operates centralised flood warning services based at the Regional Offices in the state capitals. It collects rainfall and river information, issues generalised valley flood warnings and makes flood predictions for key locations along rivers from these centres. This centralised warning service has significant advantages in both the present application and future improvement of flood forecasting techniques.

Using the current flood prediction models is not a fully objective process. Predictions must often be adjusted to reflect the effects of unusual circumstances such as an abnormal pattern of rainfall over the river catchment. These changes are best made by specialists who are thoroughly familiar with the studies and analyses underlying a flood prediction model.

Improvements on current techniques should result from better rainfall and river flow information from future floods, scientific advances in hydrology and operational experience in flood forecasting. The 'feedback' of operational experience to improvement of forecasting techniques

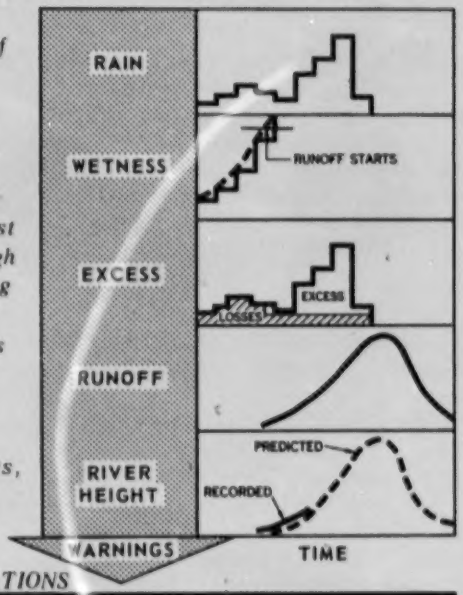
STEPS TOWARDS FLOOD FORECASTING

Catchment rainfall is determined from a network of rainfall observers . . .

The start of surface runoff is predicted from the forecast and observed rain . . .

Excess rain is derived by subtracting from forecast and observed rainfall the losses expected through evaporation, absorption by vegetation, and soaking into the soil . . .
Flood runoff at a particular time and place is predicted by applying hydrological techniques to this excess rain . . .

From this flood runoff and recorded river heights, future river heights are predicted. . .



WARNINGS SENT TO APPROPRIATE ORGANISATIONS

TYPICAL CATCHMENT: UPPER NAMOI, NSW

The complexity of flood forecasting is indicated by this diagram of the Upper Namoi catchment, with eight sub-catchments offering innumerable combinations of rainfall and flood risk. Application of rainfall-runoff techniques at 00 hours provides preliminary estimates of river flow at Brabri (peak effect 09 hours), North Cuerindi (12 hours), Tamworth (12 hours) and Carrol Gap (24 hours). Routing these flows through the system and allowing for expected discharges from Keepit Dam gives 24-30 hours warning of the effect at Gunnedah. Progressive checks against observed flows allow updating of warnings.

Figure 23.16

should be most effective when the same group of specialists develops and applies these techniques.

Two basic approaches are used to predict river behaviour. Their aim is to predict the rate of stream discharge (hydrograph curve) for a particular point on the river.

The flood routing technique depends on good stream flow information to permit forecasts based on what has happened upstream.

The second method aims at predicting the river behaviour of the reference point by deriving the surface run-off that will be associated with a given rainfall over the catchment upstream from the reference point. The total rainfall in unit time intervals (usually three hours) at selected stations is used to estimate the average depth over the catchment, and from this are subtracted 'losses' due to deep soil percolation and retention in soil and dams, etc.

Problems, problems . . .

To forecast future floods, you must have studied past floods. As modern flood forecasting is a relatively new technique, it is not surprising to find that past records are sadly deficient.

For instance, the many agencies that measure river flow (22 at last count) have networks developed for purposes other than flood forecasting. These records are sometimes inadequate from the Bureau's point of view.

Even the character of Australian streams conspires to frustrate the hydrologists who attempt to calculate the flood discharge by measuring river height, the river's area of cross-section and the water velocity through the cross-section. Unfortunately, many Australian rivers rise rapidly during flooding and spread widely beyond normal channels, particularly in their lower reaches where the need for forecasting is usually greatest, so making it difficult to determine peak discharge.

To measure an actual flood, expensive instruments and skilled teams of men are needed. Floods often occur simultaneously in several streams and measurement opportunities are limited, so such progress may take years.

Even if sufficient accurate information were available, perfect results would still not be achieved as the processes involved in the generation and behaviour of flood waves are not yet adequately understood.

The lesson of overseas experience must continue to be adapted to the Australian environment.

For example, we need to know more about hydrologic processes in the vegetation-soil complex, which are highly important in the many quick-flooding rivers. Local environmental factors are very strong here, and research is essential. Application of overseas studies alone would be insufficient.

Forecasting for forecasts

Sometimes you can't wait to see how much rain falls. You must base flood forecasts on the predicted rainfall.

Take the Macleay River at Kempsey in New South Wales. Local authorities have asked for a warning system giving a minimum of twelve hours advance warning that the river will exceed 16 feet.

Earlier rain may have brought the height to 10–12 feet. If rain now ceases, no significant flooding will occur. However, intense rain in the Kempsey area could take the height above 16 feet within 5–8 hours. So the flood forecast must

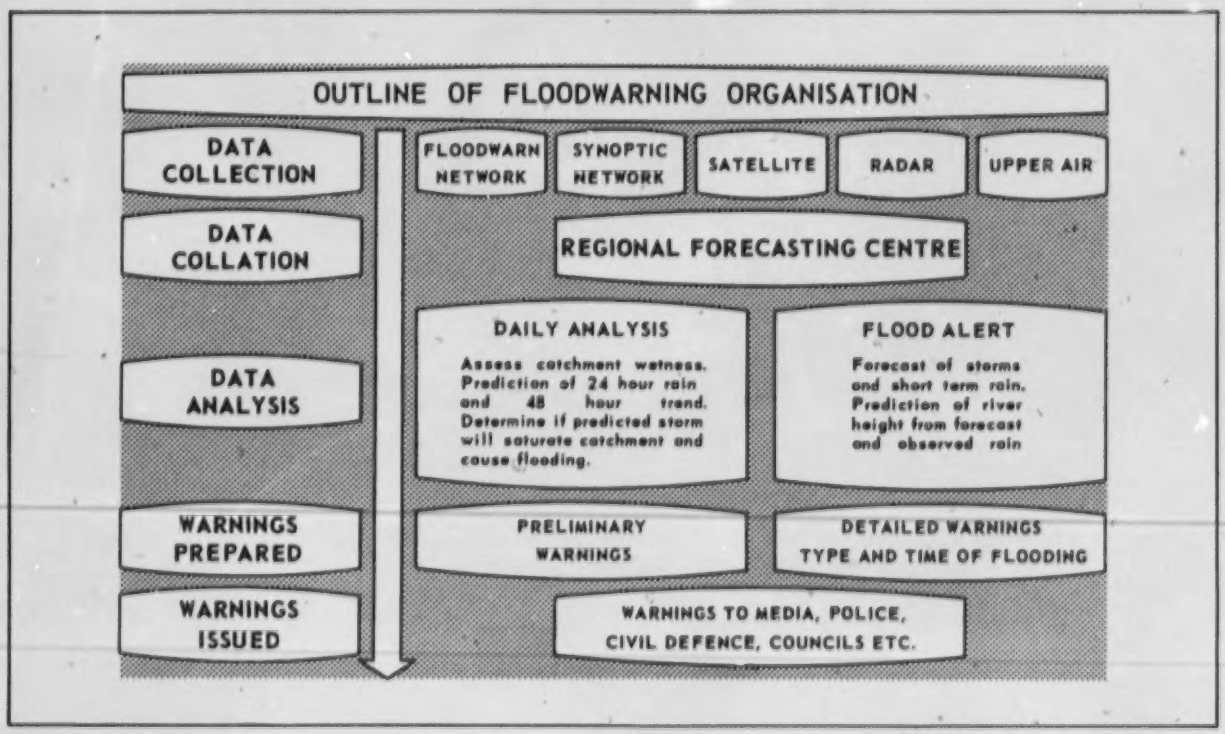

OUTLINE OF FLOODWARNING ORGANISATION
DATA COLLECTION
DATA COLLATION
DATA ANALYSIS
WARNINGS PREPARED
WARNINGS ISSUED
FLOODWARN NETWORK
SYNOPTIC NETWORK
SATELLITE
RADAR
UPPER AIR
REGIONAL FORECASTING CENTRE
DAILY ANALYSIS
Assess catchment wetness. Prediction of 24 hour rain and 48 hour trend. Determine if predicted storm will saturate catchment and cause flooding.
FLOOD ALERT
Forecast of storms and short term rain. Prediction of river height from forecast and observed rain
PRELIMINARY WARNINGS
DETAILED WARNINGS TYPE AND TIME OF FLOODING
WARNINGS TO MEDIA, POLICE, CIVIL DEFENCE, COUNCILS ETC.

Figure 23.17

take account of rain forecast for the next 6–9 hours, as well as that which has already been measured.

Such situations are frequent enough to present a serious problem, because with present knowledge the amount of rain that will fall in a 6–12 hour period cannot be forecast with high accuracy. Despite this, forecasts of rain depth demonstrate sufficient skill to make them worthwhile [see figure 23.16].

Collecting data

A network to measure rainfall and river heights is a cornerstone of a flood warning system.

Most of the Bureau's improved flood warning systems require these measurements at intervals of three hours, sometimes for two or three days. Fortunately it has been possible so far to recruit enough cooperative observers to make and report these measurements.

Bureau of Meteorology, *Annual Report, 1970-71*

Figure 23.17 shows the outline of the flood warning organisation, and figure 23.18 shows how the organisation worked in an actual situation.

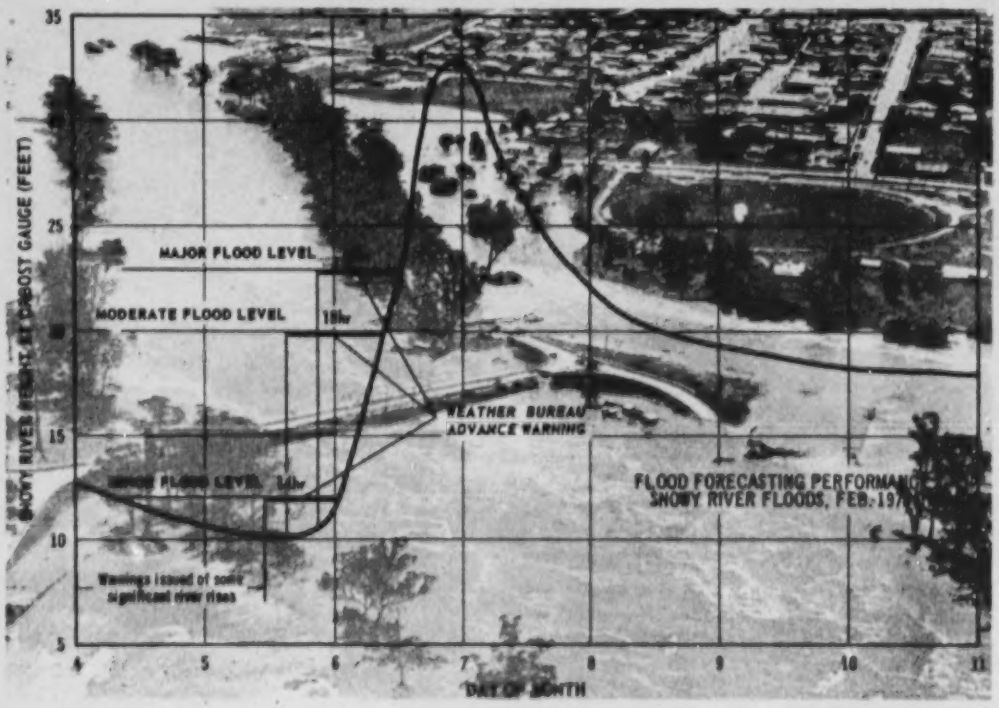


Figure 23.18

24

Subsystems of the drainage basin

A: The soil subsystem in drainage basins

The quoted material in the following discussion of soils is drawn from a publication of the Ontario Department of Agriculture, Canada.

WHAT IS A SOIL?

Agriculturally, soil is the natural medium for the growth of plants. Soil furnishes the plant an anchor for its roots as well as nutrients (including water) and oxygen for growth and reproduction. To a farmer, soil is the medium on which he expends his labours and the primary source of his livelihood.

Components of a soil

All soils consist of four components:

- mineral material
- organic matter
- water
- air.

The *mineral materials* are fragments of many kinds of rocks found in the glacial debris. This mineral fraction is often referred to as the soil skeleton or fabric. It is made up of particles of various sizes ranging from gravel and sand, which give the soil a gritty feel to silt and clay, which are smooth and sticky. The relative proportions of the various sized soil grains determine soil texture.

The *organic fraction* of a soil consists of plant roots, organisms large and small, the remains of plants and animals, and the by-products of their decay. The stable residues, humus, resulting from the decomposition of organic matter, are microscopic in size and play an important part in holding plant nutrients and water. Poorly drained soils contain more organic material than nearby well-drained soils. The organic content of clay soils is normally greater than sandy soils. A soil is classed as an organic soil (muck or peat) if the organic fraction makes up more than 20 per cent of the soil by weight.

Water is held within some of the pore spaces and as thin films around the mineral and organic materials. A soil retains more water as the amounts of clay and organic matter increase. Soil water contains many soluble nutrients required by plants.

The principal *gases* in the soil atmosphere are nitrogen, oxygen and carbon dioxide. Certain soil bacteria utilise atmospheric nitrogen and produce complex organic materials. Oxygen is essential for the growth of all forms of life. The carbon dioxide combines with soil water to form carbonic acid, which assists in the release of plant nutrients from the mineral materials.

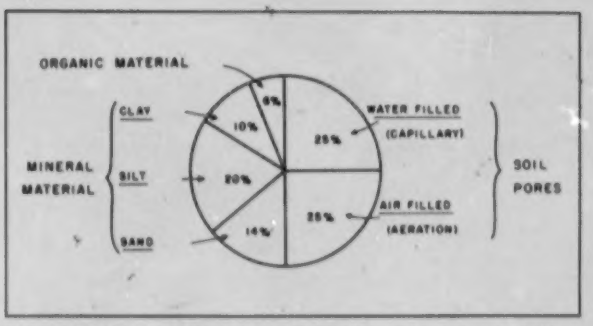


Figure 24.1: The volumetric composition of a loam soil when excess water has been removed. On a weight basis, the percentage composition of the dry soil would be: organic material 4, clay 22, silt 44, and sand 30

Factors in soil development

The study of the development (genesis) of a soil from a parent material is basic to the preparation of a system for classifying soils. Once the soils in an area have been classified, their distribution, characteristics and uses are detailed in soil survey reports and on soil maps.

The five major factors in soil development are:

- climate (temperature, precipitation)
- organisms (plants, animals, insects, micro-organisms)
- parent material (mineral material from which a soil develops)
- topography (shape of ground surface)
- time (the relative duration of soil-forming processes).

Temperature and rainfall control the rates of weathering of rocks and minerals, the leaching of soluble materials from a soil, the accumulation of organic matter, the vegetation that grows on a soil, and the organisms that live in a soil. In general, climate is so significant in soil development that the broad soil regions of the world are related to climatic regions, but they are not entirely coincident because all five factors of soil development are involved.

Soil organisms include plants, animals, insects, bacteria and fungi. The organic matter in a soil is a result of the growth and decay of these organisms. Bacteria and fungi live mainly on plant and animal residues and change the residues into a multitude of different forms. Animals and insects burrow through soil, mixing materials from different depths.

Within a given climatic zone, the physical and chemical properties of the parent materials have a dominating influence on the kind of soil that develops. Sandy materials with a low content of lime weather to acidic soils. Loamy calcitic materials develop into slightly acid or neutral soils as the calcium compounds are weathered and leached from the surface layer. Compacted clayey parent materials weather more slowly than porous sandy materials.

Topography affects soil development largely through the drainage conditions it imposes on the parent material. More water permeates the soil materials on a level area than on steep slopes, thus influencing the weathering process, the natural vegetation, and the biological activity. Water may accumulate for long periods of time in depressional areas resulting in peat bogs or marshes—soils that are permanently wet.

Time is necessary for the development of soils from parent materials. The length of time required for the formation of a given kind of soil depends largely on the other factors of soil formation. One cannot make any useful statement in terms of years regarding the time required for soil formation.

Soil profiles

Every soil has a *profile*—a succession of layers from the surface down to the parent material. These layers are known as *horizons* and are designated by the letters A, B and C. This terminology is more specific than the terms subsurface or subsoil. Horizons vary in thickness from a fraction of an inch to several feet and differ from one another in colour, texture, structure, reaction, and other soil properties. The sides of a pit, along roadside cuts and ditches are good places to study the different horizons of a soil.

Soil profiles may be grouped into three different drainage classes—well drained, imperfectly drained, and poorly drained. The appearance of well and imperfectly drained profiles differs from place to place; a similar kind of profile occurs on all poorly drained areas.

A well-drained profile

The Ah (humus) horizon comprises the surface layer from which materials are removed by percolating waters. Organic matter is most abundant and organisms and small animals are most active in the surface horizon. If an Ae (eluviated) horizon is present, it will be found immediately below the Ah and is characteristically lighter in colour than other horizons in the profile. The materials that are leached or translocated from A horizons include calcium, magnesium, iron and aluminium compounds, organic matter, and clay. It may not be possible to identify the Ae horizon of soils in cultivated fields because it may have been mixed with the Ah horizon during ploughing. Loss of the surface soil by wind or water erosion may have forced the farmer to incorporate some of the Ae with the Ah horizon to maintain a suitable depth of topsoil.

The clay and the iron and aluminium compounds removed from the A horizon tend to accumulate in the B, often referred to as the illuvial horizon. If the accumulation of clay results in a textural difference between A and B horizons the symbol Bt is used.

The C horizon occurs beneath the B, and consists of parent material, essentially the mineral fraction from which the A and B horizons were derived.

An imperfectly drained profile

If the water permeability of the parent material is slow as a result of compaction or a high clay content, the soil will show evidence of imperfect drainage. A visible evidence of imperfect drainage is a mottling of yellow, brown or reddish streaks or blotches along cracks or old root channels in the Btg and Ae horizons.

Sandy parent materials that are highly permeable may develop into imperfectly or poorly drained soils if they are underlain by an impervious layer of clay or a high water table.

The Btg horizon in imperfectly drained soils is not as clearly defined as in well-drained soils. The colours are not as bright.

A poorly drained profile

Poorly drained soils are identified by a deep, dark Ah that is underlain by a strongly mottled, bluish or greyish horizon. This horizon may be designated as a gley (Bg) (gley, from the Russian meaning bluish clay). There is an accumulation of organic materials because the decomposition of the organic material is retarded by the poor aeration.

PHYSICAL PROPERTIES OF A SOIL

Physically, a soil may be described as a porous medium comprising finely divided organic and mineral particles, rigid inactive grains (sand), and pores that contain water and gas. The proportion of the components of a soil has a major influence on its physical properties and often has a significant effect on the suitability of a soil for plant growth.

Some measurable physical properties of a soil that affect plant growth are:

- soil texture
  - —plant nutrient supply
  - —moisture content
  - —drainage
  - —workability
- soil structure
  - —movement of air and water
  - —size and function of pores
- soil porosity
  - —relative volumes of water and air
- water flow
  - —movement of water
  - —availability of water to plant roots.

Soil texture

The mineral particles in a surface soil represent about one-half the total volume or 95 per cent of the weight of a moisture-free sample. The particles may range in size from stones to fine clay particles that are visible only with a microscope. The proportion of the separates (sand, silt and clay) determines soil *texture*. Texture is a term that describes the feel of a soil when it is wetted and rolled between the fingers—sandy soils are coarse and gritty, while clay soils are sticky.

A simple way of roughly determining the proportion of sand, clay and loam in a soil is to mix a sample of the soil with water in a measuring glass from the school's science laboratory, and allow the mixture to stand. The grains of various sizes will settle out into layers and you can estimate the texture.

It is obvious that the 'feel of a soil' is not a sound method for determining the texture of a soil. Hence, it is necessary to determine by chemical and physical means the amounts of sand, silt and clay in a sample of soil. The size limits, actually diameter limits, of sand, silt and clay have been established [table 24.1] and, knowing the percentage of any two of the separates, the conventionally accepted texture of a soil may be determined by referring to a chart, an example of which is given in [figure 24.2].

Table 24.1: Particle size distribution and textural class for three soils

Soil	Sand 2·0 to 0·05 mm (per cent)	Silt 0·05 to 0·002 mm (per cent)	Clay < 0·002 mm (per cent)	Textural class from [figure 24.2]
Soil A	60	30	10	sandy loam
Soil B	40	40	20	loam
Soil C	25	40	35	clay loam

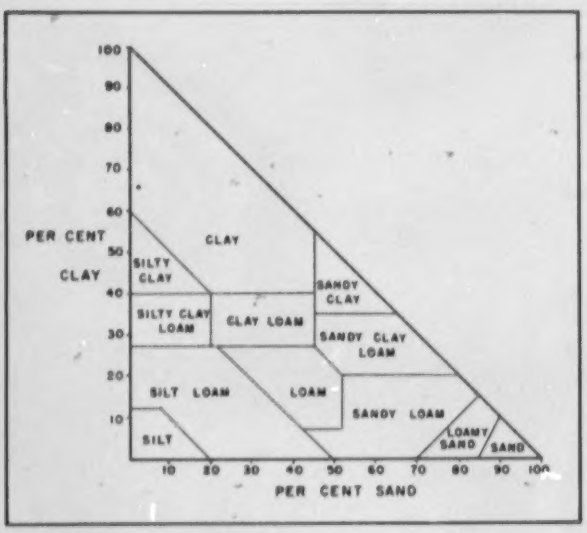


Figure 24.2: Diagram showing percentage of sand and clay in the different soil textural classes

Properties of the soil separates

Stones, gravel and sand occur in soil as single particles, often irregular or rounded in shape. . . . The large spaces that occur between the particles facilitate the free movement of water and air. Soils containing much sand or gravel are porous, have a low water-holding capacity but possess good drainage and aeration, and are usually friable and easily cultivated. Quartz is the dominant mineral in sands but particles the size of sand or larger may be composed of limestone, dolomite, or igneous rocks.

The silt particles are too small to be seen without the aid of a microscope. The small spaces between particles tend to retard air and water movement. Silt, silt loam, and silty clay soils have a high water-holding capacity. Various kinds of minerals occur in the size range of silt but quartz is most frequent.

The clay is the most important mineral separate in terms of the physical and chemical properties of a soil. Because of the minute size of the particles, a unit weight of clay has an exposed surface area many times greater than the area exposed by the same weight of sand. Clay is a storehouse for plant nutrients and is responsible for the swelling, shrinking, stickiness, and the water-holding capacities of soils. Clay soils that drain slowly and are difficult to cultivate may become highly productive if the amount of decomposing organic matter is increased and the soil structure improved. . . .

Rock fragments greater than 2 mm are classified according to size using such terms as: gravel up to 75 mm, cobbles 75–250 mm, and boulders greater than 250 mm.

Soil texture and crop adaptability

Soil texture alone is seldom the most important factor in determining crop adaptability in regions where the crops are climatically suited. It is true that flue-cured tobacco is grown almost exclusively on well-drained, coarse-textured soils because it is essential to make rather fine adjustments in fertility and moisture at critical stages in the growth of the tobacco plant, but the dominant soil requisite is good drainage. Adequate soil aeration and drainage are a must for profitable potato production and consequently the better yields are often obtained on sandy soils. However, the majority of farm crops display considerable tolerance to soil texture and the chemical composition of a soil. Most crops are less tolerant of such soil conditions as inadequate aeration, poor drainage, or low fertility.

Soil structure

Whereas texture refers to the size and the amount of the mineral particles, *soil structure* refers to the physical arrangement of mineral and organic particles into aggregates, granules, or peds of different shapes, sizes and porosities. A desirable soil structure is composed of aggregates which are:

- water stable; do not collapse when wetted
- porous; as in the aggregates under grass crops
- variable in size, ranging from small (1·0 mm) to large aggregates (2·0–5·0 mm).

Types of soil structure

Two of the major types in a classification system for soil structure are:

1. *Structureless*, which includes the single sand grains of most coarse-textured soils and the massive fragments of soil in many clay parent materials;

2. *Block-like*, in which the aggregates have flat or rounded surfaces and sharp or rounded corners.

A soil clod is not a structural unit but rather a mass of soil produced by tillage or digging, which usually slakes easily with repeated wetting and drying.

Formation of soil structure

An individual *soil aggregate or ped* is an agglomeration of minute mineral and organic particles held together by various cementing agents, such as clay, by-products of organic matter, decomposition, and iron oxide. Although a farmer is not likely to change the clay or iron oxide content of a soil, he can influence the organic matter content. Because organic material is destroyed by biological activity, new organic matter must be added regularly to a soil if a good soil structure is to be maintained. The addition of easily decomposable organic material to a soil is a feature of good soil management.

Many soil organisms produce gelatinous by-products that cement soil particles into aggregates. These organisms are most active in a soil that is well supplied with organic matter and plant nutrients. Some soils require the addition of lime to adjust the soil reaction to a more favourable environment for the organisms. . . .

Crop roots and residues, especially hay and sod crops, encourage the development of a granular structure in the surface soil by the addition of organic matter and root secretions that act as cementing agents. The minute roots compress the soil particles and dehydrate the soil, an essential step in aggregate formation.

The data in [table 24.2] illustrate the beneficial effects of grass and organic matter on soil aggregation. In the four-year rotation, soil aggregation reached its lowest level under corn but improved under each of the hay crops. It is doubtful if the percentages of organic matter under the crops in the rotation are significantly different, except for the second-year hay.

Table 24.2: Effects of crop sequences on the level of soil organic matter and aggregation in a loam soil after a ten-year period

Crop sequence*	Organic matter (%)	Aggregation % > 0·5 mm†
Continuous sod	4·4	84·7
Continuous corn	3·1	21·6
In a four-year rotation		
Corn	4·1	52·3
Oats	4·2	55·9
Hay 1st year	4·0	60·9
Hay 2nd year	4·4	74·0

*All of the crop was removed and no manure applied

†Aggregation is expressed as the percentage of a sample of air-dry aggregates that were water stable and > 0·5 mm in size.

Importance of soil structure

The presence of a high percentage of water-stable aggregates is desirable in fine-textured soils because it:

- increases porosity
- favours aeration
- aids in water movement in the profile
- increases the resistance to erosion by wind and water.

In coarse-textured soils, the sand grains occur as separate individuals with large pore spaces around the particles. Normally, the coarse particles do not agglomerate in these soils.

The maintenance of good soil structure is an important objective to be considered in planning systems of soil management.

Soil porosity and aeration

Soil porosity is defined as the fraction or percentage of the soil volume occupied by air. The total pore space is filled with air in a dry soil and with air and water in a moist soil. In coarse-textured soils, large pores occur around the individual grains of sand, but in fine-textured soils the volume and size of pores are dependent largely on soil structure.

Aeration and capillary porosities

The *total porosity* of a soil is the volume of all pores of many sizes and shapes. The relative distribution of the 'large' and the 'small' pores is an important soil characteristic.

The volume of large pores, the *aeration porosity*, is determined by measuring the volume of water that drains freely from a soil that was saturated initially. The *capillary porosity* is the volume of all the small pores that retain water after the large pores have emptied. The rapidity and ease with which excess water is removed from a soil increase as the volume of aeration porosity increases.

The total porosity of clay soils that are well supplied with organic matter and are of good structure will exceed the total porosity of sandy soils. However, fine-textured soils may be compacted by improper tillage to such a degree that the total porosity may be less than in sandy soils. Aeration porosity values serve as a criterion in judging the effects of tillage or cropping practices on soil structure [table 24.3]. . . .

Table 24.3: Soil porosity values and the weight per cubic foot of a loam soil under extreme cultural treatments

Cultural treatment	Soil porosity (percentage)		Weight (lb) per cubic foot of dry soil
	Total porosity	Aeration porosity	
Continuous sod	53	19	78
Continuous corn	49	11	84

What effects does continuous cropping of corn (table 24.3) have on soil? On which farm that you examined in studies 2–11 would these effects be occurring?

Soil aeration

When the volumes of aeration and capillary porosities are about equal, the exchange of gases between the soil air and the atmosphere proceeds normally; that is, the concentration of carbon dioxide in the soil does not reach toxic levels nor does oxygen become limiting. If the supply of oxygen is limited, the roots of most plants die, the intake of water and plant nutrients is reduced, and toxic compounds of iron, manganese and nitrogen may reach concentrations that are harmful to plant growth.

Soil moisture

Moisture occurs in soil as a gas in the soil atmosphere, as a water film around the mineral and organic particles, and as free liquid in the pore space. The volume of water retained by a soil increases as the particles and pores decrease in size. While the volume of water in the soil atmosphere is negligible, it is important to realise that only in very dry soils does the relative humidity of the soil atmosphere fall below 95 per cent. The moisture in the soil atmosphere contributes to the growth and activity of the micro-organisms.

The drainage process

A soil is saturated with water when all the pores are filled, a condition that seldom occurs in the surface layer of a well-drained soil in the field. Water drains from the large pores and moves downward under gravitational forces. The thickness of the water films around the particles and aggregates is reduced as a pore is emptied. Drainage continues as long as bridges or saddles of moisture exist between soil particles. The rate at which water is removed by natural drainage decreases as the number of bridges decreases and as successively smaller pores are emptied. When the movement of water by natural drainage from an initially saturated soil has virtually stopped, the moisture retained by a soil is referred to as the field capacity value.

Field capacity

In the preceding paragraph, the moisture at *field capacity* was described as the maximum amount of water a well-drained soil can retain against gravitational forces. The moisture is present in two sites: (1) in relatively thick films around the mineral and organic particles that were not connected by bridges of water, and (2) in the small capillary pores that were able to hold the moisture against the gravitational pull.

If a soil with the moisture at field capacity receives additional water by rainfall or irrigation, a layer of soil (the thickness of the layer depends on the amount of water) approaches a saturated condition and the drainage process starts again. Thus, in irrigating a soil a farmer should apply enough water to raise two or three feet of soil (the rooting zone) to its field capacity value. Additional water would be lost through natural drainage.

Permanent wilting point

As a soil dries out, it becomes increasingly difficult for plants to remove water from it. If water is not added, the soil becomes so dry that the rate of moisture absorption by the roots is slower than the loss of moisture through the leaves (transpiration). At this point the plant wilts, ceases to grow, loses its rigidity, and eventually dies.

Available, hygroscopic and gravitational water

Water between field capacity and the permanent wilting point is *available* for plant use. Moisture beyond the wilting point is called *hygroscopic* moisture and is held so strongly by the soil that plant roots cannot develop enough 'suction' to remove it. The moisture between saturation and field capacity is classed as *gravitational* because in well-drained soils it drains away readily. Gravitational water is not considered as available water as it does not remain in a well-drained soil for any great period of time. The relationships between these moisture characteristics for a clay soil and a sandy soil are illustrated in [figure 24.3].

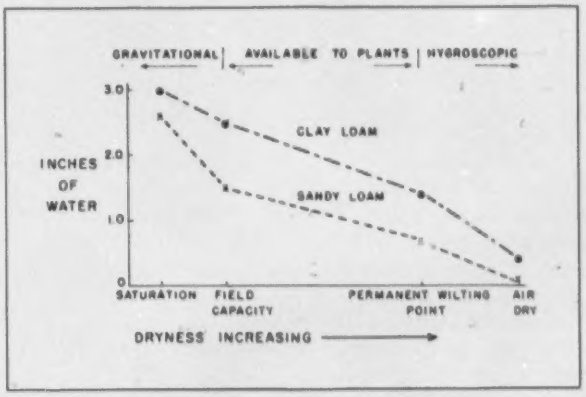


Figure 24.3: The inches of water retained in the surface six-inch layer of two soils (a clay loam and a sandy loam) at four degrees of dryness

SOIL BIOLOGY

In addition to the plant life in a soil, other important forms of life include:

- animals (burrowing animals, earthworms, insects, snails, nematodes)
- micro-organisms (bacteria, fungi, actinomycetes, algae).

The many forms of animal life in a soil live on fresh or decaying vegetation. Earthworms consume large amounts of organic matter and excrete it in a partially digested form which is easily decomposed by bacteria. Animals tend to change and aerate a soil by their burrowing and soil mixing.

Soil bacteria outnumber all other forms of micro-organisms in a soil. Most bacteria are beneficial because they release plant nutrients as they carry on their life cycle. Besides moisture, heat and essential minerals, micro-organisms require carbon as a constituent of their cells, nitrogen that has been combined previously into mineral or organic forms for the protein in their body, and a supply of material that they may oxidise (decompose) to provide them with energy.

The autotrophic bacteria obtain their energy from the oxidation of simple chemical compounds, and their carbon from the carbon dioxide in the atmosphere. This group of bacteria oxidise sulphur to sulphates, and ammonium compounds to nitrites to nitrates. This conversion of ammonia to nitrates is called nitrification and the autotrophic bacteria are an important agent in this conversion.

The heterotrophic bacteria depend upon organic matter for their source of energy and supply of carbon. This group of bacteria are largely responsible for the decomposition of organic matter and the production of the gas, carbon dioxide. Also classed as heterotrophic are the symbiotic (living together) bacteria. They live in the nodules of the roots of legume plants and use the nitrogen in the atmosphere to build their body protein. The nitrogen in the

nodules is made available by bacterial decomposition to the legume plant or other plants, such as grasses, that may be growing with the legume, or to a crop that may follow the legume.

Fungi break down some of the more resistant forms of organic matter such as cellulose and lignin, and certain readily decomposable compounds, including sugars, starches and proteins. The remains of dead fungi are not readily decomposed and form a part of soil humus. Some fungi cause plant diseases such as rusts, wilts, blights and smuts.

The primary function of soil actinomycetes is in the decomposition of the moderately resistant forms of organic matter. Actinomycetes produce antibiotics that have been isolated and are known as streptomycin, aureomycin and others. Potato scab is caused by an actinomycete.

Soil algae are chlorophyll-bearing micro-organisms and may give a moist surface soil a greenish cast. They add some organic matter to a soil.

SOIL MANAGEMENT

Two objectives of a soil management programme for climatically adapted farm crops are to produce the greatest net returns (dollars) per acre and to maintain or improve soil productivity, both on a long-term basis. It will be shown later that a management programme that results in maximum crop yield is not necessarily the most profitable one.

A good soil management programme involves:

- the maintenance of adequate levels of soil fertility and soil organic matter
- the use of suitable tillage methods, depending on the soil and the crop
- the control of soil moisture, when necessary, by drainage or irrigation
- the use of special measures to control erosion when crop cover alone is not adequate.

Maintenance of soil fertility

A fertile soil supplies the essential nutrients in a suitable form, in adequate amounts, and in a proper balance for the growth of plants. If the supply of available nutrients limits crop yield, it may be increased by the addition of specific chemical fertilisers. There are many possible levels of fertility in a soil. The highest level is usually established for the crops with the greatest net dollar return per acre.

Nutrient losses

A low level of soil fertility results when cropping removes the available nutrients more rapidly than they are replenished. The supply of available nutrients may be reduced by the conversion to fixed forms in the soil, by leaching, and by erosion.

Removal by crops

Grain crops remove more nitrogen from the soil than any other essential element. Forage and vegetable crops, with few exceptions, contain more potassium than nitrogen. The average contents of nitrogen, phosphorus and potassium for most farm crops are given in [table 24.4]. Except for some of the nitrogen in legumes, all of the essential elements in the plants come from the soil.

Table 24.4: Plant nutrients contained in farm crops

Crop	Yield	Part of crop	Pounds		
			Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)
Barley	50 bus.	grain	43·6	18·7	12·5
	2 500 lb	straw	18·7	6·2	37·5
			62·3	24·9	50·0
Beans	25 bus.	seed	60·0	18·0	19·5
	2 000 lb	straw	28·0	6·0	38·0
			88·0	24·0	57·5
Buckwheat	20 bus.	grain	15·0	6·0	3·0
	5 000 lb	straw	62·5	7·5	57·5
			77·5	13·5	60·5
Corn	75 bus.	grain	71·2	28·7	18·7
	4 500 lb	stover	47·5	15·0	68·7
	750 lb	cobs	3·0	0·6	3·3
			121·7	44·3	90·7
Flax	15 bus.	grain	30·5	12·5	8·2
	1 800 lb	straw	20·5	3·4	18·8
			51·0	15·9	27·0
Oats	75 bus.	grain	52·5	22·5	15·0
	3 750 lb	straw	22·5	7·5	52·5
			75·0	30·0	67·5

Crop	Yield	Part of crop	Pounds		
			Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)
Peas canning	1 800 lb	grain	66·0	15·4	18·0
	4 500 lb	straw	45·0	8·5	47·7
			111·0	23·9	65·7
Rye	30 bus.	grain	28·6	14·7	10·0
	3 000 lb	straw	15·0	9·0	25·5
			43·6	23·7	35·5
Soybeans	25 bus.	grain	110·0	35·0	40·0
	2 500 lb	straw	15·0	5·0	20·0
			125·0	40·0	60·0
Tobacco	1 500 lb	leaves	55·0	10·0	80·0
	1 500 lb	stalks	25·0	10·0	35·0
			80·0	20·0	115·0
Wheat	40 bus.	grain	46·6	21·3	12·0
	3 330 lb	straw	20·0	5·3	28·0
			66·6	26·6	40·0
Mangels	20 tons	roots	60·0	40·0	140·0
Potatoes	300 bus.	tubers	65·0	25·0	115·0
		tops	60·0	10·0	55·0
			125·0	35·0	170·0
Sugar beets	15 tons	roots	55·0	22·0	53·0
		tops	60·0	23·0	92·0
			115·0	45·0	145·0
Turnips	10 tons	roots	50·0	20·0	90·0
Alfalfa hay	3 tons	all	140·0	30·0	135·0
Bluegrass hay	2 tons	all	53·0	21·6	84·0
Millet hay	3 tons	all	75·0	27·0	90·0
Red clover hay	2 tons	all	80·0	20·0	70·0
Soybean hay	2 tons	all	92·0	28·0	44·0
Sweet clover hay	5 tons	all	185·0	45·0	165·0
Timothy hay	1·5 tons	all	40·0	15·0	45·0

Conversion of nutrients

The conversion or the fixation of available nitrogen, phosphorus and potassium to less available forms occurs in all soils. The soil conditions favouring conversion generally differ for each element. . . .

Loss of nutrients by leaching

Losses of plant nutrients by leaching are inevitable and the extent of the losses varies with the nutrients, soil type, management and weather. Greatest leaching usually occurs in the well-drained, coarse-textured soils. . . . Phosphorus is fixed in a soil and is not lost by leaching.

Losses by erosion

The topsoil is the most fertile layer of soil but if left unprotected by crop cover it may be slowly removed by surface run-off, even on gentle slopes. The loss of the organic material and the mineral colloids represents losses of plant nutrients. Soil erosion is discussed later in a separate section.

Supplying nutrient needs

. . . In considering the quantities of nutrients removed by the harvested portion of crops [table 24.4] it is important to realise that these nutrients came from the readily available supply in the soil. A knowledge of the amount of nutrients removed from a soil by a crop is used only as a guide in estimating fertility needs; one must have a knowledge of the unique plant nutrient relationships in a soil. In determining the nutrient needs of a soil that is to grow a particular crop, the usual procedure is to

- diagnose the problem
- determine the nutrient or nutrients needed.

Diagnose the problem

Poor crop growth may indicate a low level of several nutrients or a deficiency of one nutrient. Crop growth may be retarded by inadequate aeration, excess moisture, or a deficiency of moisture. Virus diseases and insect injuries may cause symptoms that could be mistaken for nutrient deficiencies.

Determine the nutrients needed

The cause of poor crop growth is seldom determined by visual symptoms alone. Soil and crop specialists often use field plots, greenhouse trials, and soil and plant tissue tests as diagnostic tools. Ontario farmers are advised by specialists regarding the nutrient status of their soils. The advice and recommendations are based on the results of chemical tests on a sample of soil submitted by a farmer, a knowledge of the kinds of soil on the farm, and the crops that are to be grown.

Chemical soil tests

Chemical tests on a soil are used to estimate the amounts of:

- certain ions (potassium, calcium, magnesium) that are readily exchangeable and available to a plant
- soluble nutrients (nitrogen, phosphorus, potassium, calcium and magnesium) and in certain instances the concentration of toxic compounds
- nitrogen that might be released from organic compounds under ideal conditions of temperature and moisture
- hydrogen ions and basic compounds as a guide to changing soil pH.

The quantity of a nutrient as shown by soil tests cannot be used directly to calculate the pounds of that nutrient needed for a given crop yield. The chemicals used to extract the nutrients do not exactly imitate the plant roots and, furthermore, the rooting system of a plant does not contact all the available nutrients in a soil as the chemical extractant does.

Soil test values are most useful when they have been calibrated for different crops under field conditions. Soil testing is a necessary tool to assist farmers in selecting the kind of fertiliser and the amount to apply. . . .

Think back to the farmers you examined in studies 2–11. Make a list of the way they destroyed or maintained soil fertility. Did each manage the soil well?

LAND DRAINAGE

Land drainage is a special management practice that removes surplus water from the soil at certain seasons of the year and also lowers the water table. . . . Land is drained primarily to improve agricultural productivity and increase farming efficiency by greater crop yields, wider choice of crops, and more timely tillage and harvesting operations.

Where needed

Soil colour is a useful indication of the soil drainage conditions. A very dark surface soil is normally a reflection of poor drainage—the decomposition of organic residues is slow and incomplete due to poor aeration. A water table that is close to the surface or that fluctuates during the year results in soil horizons (Ae, B or C) that are a mottled brown, yellow or grey in colour or causes a gley horizon. . . .

Types of land drainage

Surface drainage is a method of collecting and removing excess water from the soil surface. Complementary practices, such as land levelling and ploughing in narrow bands, assist in the collection of the water and its discharge into drainage ditches or grassed waterways. Surface drainage may be used in areas where soil permeability is too slow for a subsurface drainage system to be effective.

In subsurface drainage, water moves through the soil into tiles made of fired clay or concrete, or into perforated pipes, and is discharged into a drainage ditch or a suitably prepared outlet. The planning and designing of subsurface drainage systems require a knowledge of the permeability characteristics of the soil and the crops that are to be grown.

In making a decision for or against a major expenditure on a land drainage system, a farmer should consider:

- the cash value or feeding value of adaptable crops
- the soil texture (the permeability of some clay soils is so slow that a subsurface system is not effective)
- the availability of good drainage outlets
- the proportion of good and poor land in the area to be drained.

Some of the benefits of land drainage are that it:

- increases the number of climatically adaptable crops that may be grown
- increases the resistance of a plant to drought by promoting deeper and more extensive rooting
- reduces the frequency of crop heaving and winter-killing
- improves soil aeration and soil structure
- permits earlier tillage (the soil dries out faster)
- promotes earlier growth (a dry soil warms up faster).

Which farmers in studies 2–11 used drainage to improve farm productivity? Why did each do so?

SOIL TILLAGE AND TILTH

Experience has taught that a certain amount of soil tillage is required for crop production. Besides controlling weeds and incorporating crop residues, soil tillage provides a seedbed and an environment suitable for plant root growth.

Soil tilth

The word *tilth* is frequently used to describe the fitness of a soil and its suitability for the germination and growth of specific seeds. A fine tilth is required for small seeds, such as grass seed, whereas a coarser tilth is suitable for the larger seeds, such as beans and corn. Tilth describes soil structure in terms of the size-distribution of the soil aggregates and their resistance to breakdown by tillage and by the action of rainfall.

The preferred sizes of aggregates range from 1 to 5 mm. A soil with large and stable aggregates has large stable pores which, ideally, extend from the surface to the water table or tile drains. Such pores ensure a rapid intake of water at the soil surface and facilitate the natural drainage of the excess water downwards. Moisture for plant use is stored in the small pores, which are distributed throughout the soil, and within the soil aggregate itself. This moisture is not removed by gravitational forces during drainage.

It is essential that the individual aggregates maintain their stability for several weeks after the seeds are planted. If the aggregates disintegrate after wetting and drying, a crust may form on the soil surface. Firm and thick crusts impede the entry of water, may restrict soil aeration, and reduce seedling emergence.

When a soil is in good tilth, there is a close contact between the seed and the aggregate, permitting moisture to move into the seed and start germination. That is why farmers prepare a 'fine, firm seedbed', use press wheels on various planters, or compact the soil by different kinds of land rollers, particularly after planting spring grain underseeded with a grass-legume mixture. It must be recognised that only the volume of soil extending an inch or so away from the seeds affects the movement of moisture to the seeds. The soil between the rows is not part of the seedbed and accordingly should be left loose to facilitate water entry and aeration. . . .

SOIL EROSION

Erosion of soil by water occurs when particles are detached by raindrops and transported by flowing water. . . . The erosion process is completed when the soil is deposited in a place other than its natural or original position.

Mechanics of erosion

Soil detachment

In some storms the raindrops strike the soil with enough energy to blast the granules apart. Water and soil splash into the air. The results of the splashing action are often seen on walls of buildings where muddy spots occur several inches above the level of the ground. On sloping land most of this splash goes down the hill, causing more soil to be deposited at the base of the hill. On a smaller scale, the splash material tends to accumulate in small depressions.

Soil transport

Water flowing over the land surface is the main agent by which soils are transported. The erosive action of water becomes greater with increases in:

- the slope of the land
- the volume of water
- the amount of abrasive material (sand and gravel) carried by water.

If the water is confined in a rill or gully, its ability to erode increases as the velocity increases and as the amount of soil being transported increases. . . .

Control of erosion

Principles of erosion control

Three principles in the control of erosion are:

- reduce the velocity of run-off water
- maintain a high infiltration rate in the soil surface
- dissipate the energy of raindrops on crops or residues.

Long slopes allow flowing water to build up its velocity and hence increase its ability to erode. If an obstacle is placed in the path of the water, its velocity is reduced; in a hay field many obstacles reduce the velocity of the water and erosion seldom occurs. A farmer has no control over rainfall nor is it completely feasible to change the slope of the land, but he can effect some control over the moving water by the selection of crops and by soil management.

Infiltration is the process whereby water enters the immediate surface of a soil. Coarse-textured soils or soils with a high percentage of water-stable aggregates usually have a high infiltration rate. A farmer does not attempt to change the texture of a soil, but he can alter soil structure by the choice of crops, the crop sequence, and the cultivation practices. If water fails to infiltrate the soil surface, then it has no alternative but to run off and transport the detached soil particles.

The erosion hazard is reduced greatly when the energy in falling raindrops is dissipated on crops or mulches of crop residues, instead of on the bare soil. This is another reason why erosion seldom occurs in unpastured woodlots or in well-managed hay and pasture fields.

Crops and crop rotations

A farmer should plan his crops and rotation so that highly erodible land is kept covered with grass as long as possible. On gently sloping land a 4- to 6-year rotation with 1 or 2 years of grain or row crops is followed. On level or nearly level soils, a 3- or 4- rotation with two or more years of grain or row crops is common. Continuous cropping with wide-spaced row crops should not be practised on sloping or erodible land.

Table 24.5: Ten-year average of soil and water losses from a loam soil on a 7 per cent slope under several cropping practices

Cropping practice	Erosion losses per year	
	Inches of water	Tons of soil per acre
Continuous sod Hay in a 4-year rotation of corn-oats-hay-hay	trace	trace
Planted with the slope		
Continuous corn	1·2*	8·4
Corn after two years of hay	0·2	0·6
Oats after corn	0·5	2·7
Planted across the slope		
Corn after two years of hay	trace	trace
Oats after corn	trace	trace

*Represents about 7 per cent of the total rainfall

The data in [table 24.5] and the results from chemical and physical analyses in [table 24.2] indicate that:

- a dense cover crop (hay) effectively controlled erosion by reducing the velocity of moving water, by increasing the infiltration rate, and by absorbing the energy of falling raindrops
- under continuous corn with residues removed, erosion was serious because the soil organic matter content had decreased and the percentage of water-stable aggregates was low (see [table 24.2])
- under corn after two years of hay, erosion was negligible because the granular and water-stable structure following the hay crop was able to withstand the beating action of the rain
- erosion under the oats was due mainly to the practice of ridge-rolling for the small grass and legume seeds
- across-the-slope planting provided numerous dams and depressions to slow down the movement of water and allow it to infiltrate.

Strip cropping

Strip cropping is an erosion control measure that may be used on long, smooth slopes that are planted to grain or row crops. It consists of maintaining strips of hay alternately with strips of grain or row crops. The width of the strips varies from 60 to 150 feet, depending on the length and steepness of the slope, the erodibility of the soil, and the crop rotation. In other words, the greater the erosion hazard, the narrower the strips.

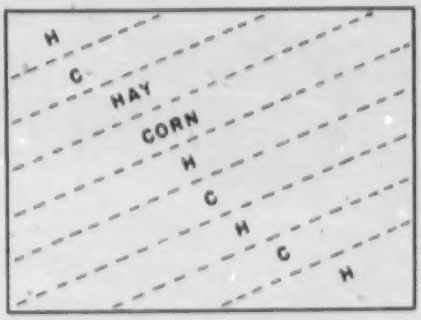
In field strip cropping, the strips are straight, of uniform width, and are laid out across the general slope of the land. Field strips are recommended on uniform slopes where it would appear that no greater control of erosion would be attained by contour strips [figure 24.4A].

If it is necessary to lay out strips that follow a contour more precisely than field strips do, a type of contour strip cropping may be used. A procedure for laying out two types is suggested. (A contour is an imaginary line connecting points of equal elevation on the surface of the soil. In the field, a contour is marked with a row of stakes or a shallow furrow.)

1. Curved and even-width strips [figure 24.4B]:
- Stake out a key contour (K.C.) at the steepest part of the field.
- Lay out even-width strips above and below the key contour.
- The second key contour will result in a correction strip which is usually left in sod.

FIELD STRIP CROPPING

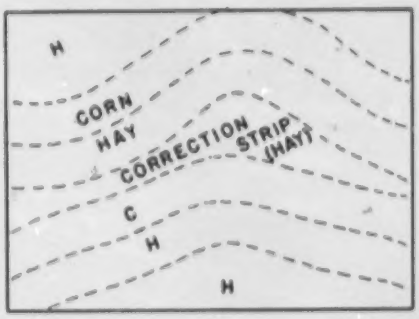
- *straight and even-width strips at right angles to the slope*
- *adaptable to uniform slopes*
- *corn and hay strips alternate*
- *gores or irregular areas kept in hay, seldom in corn*



A

CONTOUR STRIP CROPPING

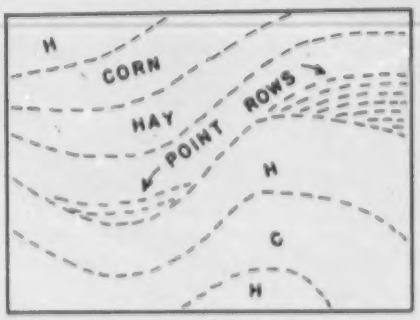
- *curved and even-width strips at right angles to the slope*
- *serious deviations from contour remedied with correction strip*



B

CONTOUR STRIP CROPPING (Exact)

- *curved and irregular width strips*
- *upper and lower edge of each strip on the contour*
- *awkward situations for plowing, planting and harvesting, for example, point rows in a row crop*



C

Figure 24.4: Three types of strip cropping

- Continue laying out strips from the second key contour.

2. Curved and uneven-width strips [figure 24.4C]:
- Upper and lower edges of all strips follow a contour.
- Results in uneven-width strips with odd-shaped areas (point rows) that present problems in cultivation, seeding and harvesting. . . .

The advantages of strip cropping are as follows:
- reduces the velocity of the water flowing over the surface
- increases the time for water to infiltrate
- encourages a farmer to use a crop rotation
- facilitates contour cultivation.

Grass waterways

Grass or sod waterways are specially prepared water courses that remove surplus water without causing erosion. Many open ditches or gullies that are impassable to machinery may be changed to grass waterways by re-shaping and seeding to grass and legumes.

A grass waterway is a broad channel with gently sloping sides and is shaped by plowing or grading. The larger the area that is drained, the wider the waterway must be; a channel less than 20 feet in width is seldom recommended. After the channel has been shaped, a mulching with straw or manure and a light seeding of oats will hold the soil in place until the grass and legumes become established. Waterways should be established when the remainder of the field is in hay.

It is essential that the waterway be kept in a grass-legume mixture and harvested for hay. The strips should be fertilised regularly, not be used as lanes and not disturbed by ploughing or cultivation.

Diversion ditches

Diversion ditches or diversion terraces are low embankments of soil thrown up on slopes for the purpose of diverting surface water away from the land farther down the slope. These channels, about 30 feet in width, are left permanently in sod regardless of the crops above or below. The sides of the ditches are gently sloped and present no difficulty in hay removal.

Three situations where diversion ditches are used:
- to break up long uniform slopes if strip cropping is not controlling erosion
- to divert water while gullies are being repaired or while grass waterways are being established
- to protect buildings or property from periodic flooding.

The water from diversion ditches may be discharged into established grass waterways and from there to unpastured woodlots or into a sod field where erosion and gullying will not develop.

Which farmers in studies 2–11 used any of these methods? Were there any farms on which they should have been applied?

Gully erosion and control

Gullies are formed when large volumes of water are confined to a narrow channel. They may develop in all types of soils but are most common in Ontario in sandy soils where intertilled crops such as corn, soybeans or tobacco are grown. Deep gullies have formed in clay soils adjoining river channels and lakeshores.

Some of the common situations that lead to gullies being developed are:
- wheel tracks in loose soil
- dead furrows
- livestock paths
- neglected natural water courses
- discharging water from yards or waterways onto soils without adequate plant cover.

Gully erosion is seldom controlled by dumping stones, brush, or old wire fencing in the channel. The water flows around the rubbish and gouges out the side, or accumulates behind an obstacle and, when suddenly released, creates a worse gully. To stop gullying and allow the sides and bottom to be covered with vegetation, it is necessary to reduce the velocity of the water along the full length of the gully by one or more of the following:
- a series of check dams of logs, boards, or sandbags placed across the gully at frequent intervals
- placing 1 to 3 feet of straw in the channel and anchoring it down by brush 8 to 10 feet in length with the trunk end placed upstream.

Large gullies, such as occur along lakeshores, require costly remedial measures. The gully walls must be pushed in, graded, and stabilised by vegetation, stonework or concrete structures.

EROSION IN THE EPPALOCK CATCHMENT

One area of Victoria that has been severely eroded is the Eppalock Catchment (figure 24.5). Before Europeans settled there the catchment had certain characteristics (see figures 24.6 and 24.7). Concentrate your attention on the topography and natural vegetation and briefly summarise the features of the catchment.

Figure 24.8 shows the average monthly rainfall and potential evapotranspiration at three towns ranging from north to south through the area. In what months is there an excess of rainfall at each station? What will happen to this excess?

When farmers first moved into the area, they did four things:
- cleared the woodland
- cultivated the land to the normal European fine tilth
- grazed the land with sheep according to the normal European carrying capacity
- introduced rabbits.

What would the effects of these actions and practices have been?

Figures 24.9 and 24.10 show what happened in the Kimbolton land unit of the Sandon land system. Here rainfall was low (500–550 mm) and there was originally natural woodland. The removal of trees meant that any excess water was not taken up by the tree root systems: there was more run-off, and more water was free to infiltrate the soil.

Refer to figure 24.15. This describes the Kimbolton land unit. Topographically, the unit consists of alternating ridges and valleys. Figures 24.11–24.13 show more of the nature of the soil and the

Figure 24.5: The Eppalock Catchment

damage done to it. At the lowest levels salting occurred, as excess water moving underground raised the water table and the salt in it to ground level (see figure 24.14).

As most of this deterioration occurred in the northern low-rainfall areas, the Soil Conservation Authority's work was concentrated there (figures 24.16 and 24.17). The planners had to work on total catchment areas, because work on one farm may be useless if the neighbouring farmers do not participate.

Figures 24.18 and 24.19 show one structure used in the project. From these photographs, explain how the structure works. What advice would you give on farming practices and types of land use suited to this area?

These brief accounts of two properties, from a Soil Conservation Authority publication, show the results of the project.

Property A

This property of approximately 900 acres was bought by its owner in 1956. Following is an extract of the initial inspection report by an Authority officer written in 1960:

'Overgrazing has resulted in extreme degradation of the property, reducing the stock carrying capacity to ¼ sheep/acre.

'Early in 1956 the owner contour furrowed approximately 60 acres on the western boundary. Because of the tendency of furrowing, without pasture improvement, to aggravate tunnelling, such treatment was abandoned.

'The owner employed a contractor to fill some of the smaller gullies and construct a number of diversion banks. Lack of protection of the former and incorrect siting of the latter resulted in further deterioration of the land so treated.'

Erosion included sheet erosion, rilling, deep gullying, severe tunnelling, stream bank erosion and siltation. It was estimated that a minimum of $8.50 per acre would have to be spent to stabilize the worst of the existing erosion. Efforts at carrying out piecemeal improvements had repeatedly met with failure.

By 1960 selective topdressing and some 200 acres of chisel ploughing without seeding nevertheless had enabled the owner to increase his stocking rate to 580 sheep or just over ½ sheep/acre. Wool production in that year was seventeen bales.

Between 1961 and 1966 a systematic programme of pasture improvement by chisel seeding was implemented and a total of 800 acres was eventually sown. Annual topdressing of improved pastures became a regular feature.

Despite the fact that a substantial area, varying from 88 to 185 acres annually, was out of production during that period, the number of sheep carried increased steadily. By 1965 stock numbers had doubled again and so had the wool clip. In 1970 this property that once carried 580 sheep and produced seventeen bales of wool from 900 acres carried 1780 sheep and produced eighty-one bales of wool. The target is 100 bales and, seasonal conditions permitting, this now seems attainable. It will necessitate putting on another 500–600 sheep and increasing the stocking rate to approximately 2.7 sheep/acre.

. . . This property is in what used to be the most deteriorated and eroded part of the whole of the Eppalock Catchment. Within that area it was one of the worst affected. . . .

Today there is little or no active erosion and the level of fertility is constantly increasing. The value of the land was recently estimated at a figure of more than ten times that of the purchase price. [Table 24.6] shows how pasture improvement has affected production over the ten-year period of the project.

Property B

Erosion on this property of 765 acres was not quite as severe as on property A and the per acre cost of erosion control works was estimated at $6. As on property A, a systematic programme of pasture improvement was commenced (in 1962). It was completed in 1966 after a total of 576 acres had been treated. Although in an area of somewhat better rainfall and soil, the initial stocking rate and carrying capacity were about the same as on property A. An all-wether flock was run as against a mixed flock on property

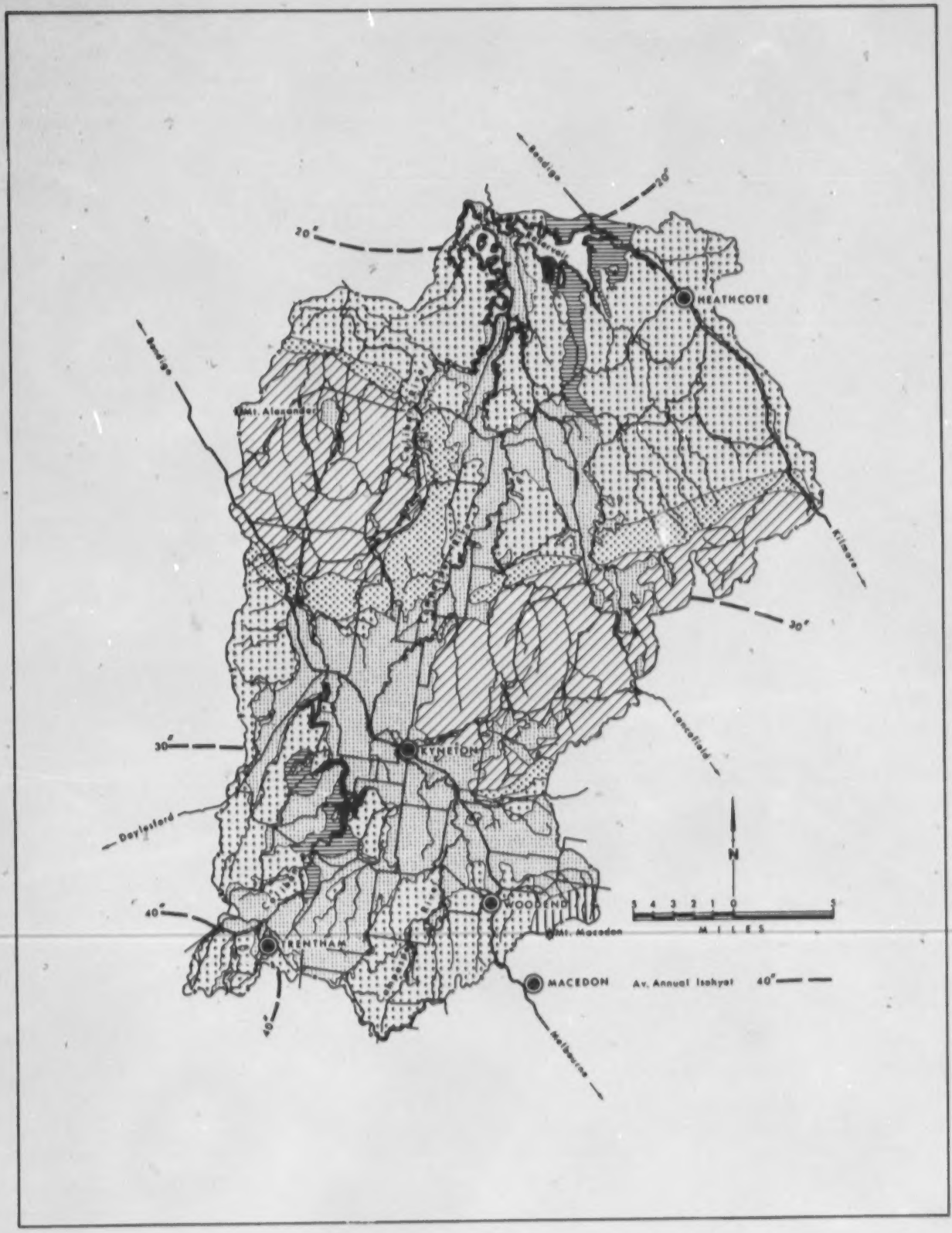


Figure 24.6: Land systems in the Eppalock Catchment (see figure 24.7 for key)

Land System.	Geology.	Topography.	Native Vegetation.	Soils.	Hazards.
Sandon	Ordovician, interbedded slates and sandstones with quartz reefs.	Dissected ridges with narrow alluvial swales.	Woodland in North. Forest in south.	Shallow stony gradational soils. Reddish duplex soils. Yellowish duplex soils on alluvium. Friable reddish gradational soils in south.	Severe sheeting in north. Severe gullying in centre and north. Severe salting in centre and north.
Moolort	Upper Pliocene to Pleistocene volcanic rocks, mainly basalt.	Dissected plateaux. In south gently dissected uplands. Volcanic cones.	Grassland. Savannah. Woodland. Forest in south.	Stony shallow gradational soils (red, brown, grey). Duplex soils (red, brown, grey). Grey calcareous clays. Reddish friable clays.	—
Ravenswood	Devonian granitic rocks, mainly granodiorite.	Gentle to moderately steep ridges with narrow alluvial swales.	Woodland. Forest.	Reddish yellow duplex soils with coarse sandy A horizons.	Slight gullying and salting.
Derrinal	Permian tillites (glacial).	Dissected plains, usually gentle slopes.	Woodland.	Reddish yellow duplex soils.	Severe salting, moderate gullying.
Metcalfe	Contact metamorphic rocks—spotted slates, hornfels, sandstones.	Ridges.	Woodland. Savannah woodland.	Shallow stony loams. Reddish duplex soils.	Severe sheeting and gullying. —
Macedon	Devonian dacite.	Mountain.	Forest.	Stony gradational soils. Yellowish brown duplex soils. Reddish friable duplex soils. Gradational soils with dark A horizons.	—
Archdale	Tertiary fluviatile sands, gravels, clays (lateritised).	Dissected plain.	Woodland. Heath woodland.	Ferruginous reddish duplex soils.	—

Figure 24.7: Key to figure 24.6

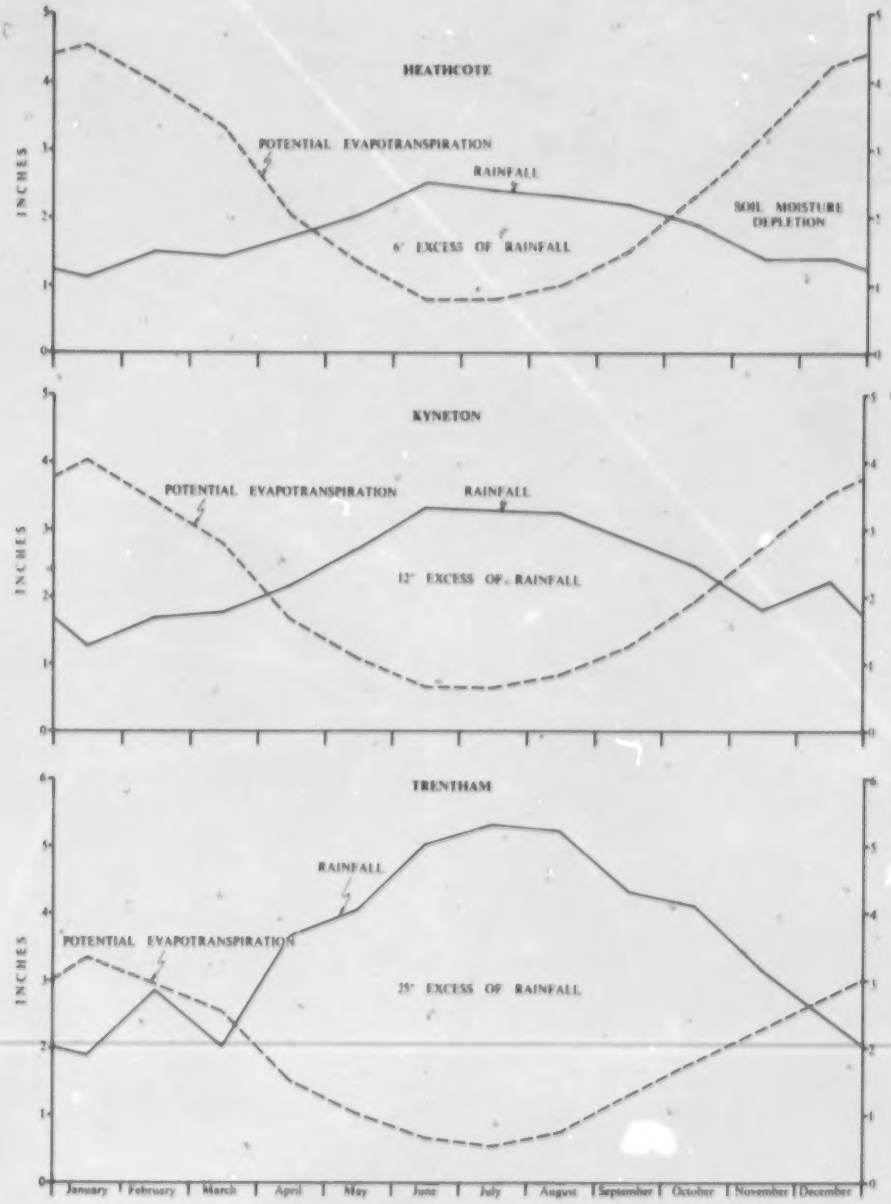


Figure 24.8: Average monthly rainfall and potential evapotranspiration (inches) in the Northern (Heathcote), Central (Kyneton) and Southern (Trentham) parts of the Eppalock Catchment

Figure 24.9: Gullying in the Kimbolton land unit

Figure 24.10: Tunnel erosion—how would the introduction of rabbits have assisted this erosion?

Figure 24.11: A road-cutting through a ridge—component 1 of the Kimbolton land unit. Describe the character of the ground layer

Figure 24.12: Gullying in the Kimbolton land unit, component 3. In figures 24.12 and 24.13, what has been deposited on the surface?

Figure 24.13: Gullying in the Kimbolton land unit, component 2

Figure 24.14: Salting in the Kimbolton land unit

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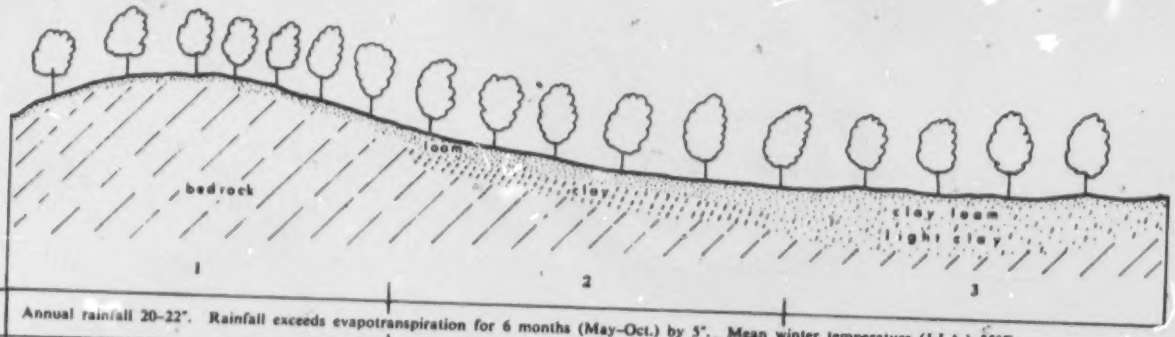


Component	1	2	3
Climate (average)	Annual rainfall 20–22". Rainfall exceeds evapotranspiration for 6 months (May–Oct.) by 5". Mean winter temperature (J.J.A.) 55°F.		
Geology	Ordovician, interbedded, steeply dipping slates and sandstones, with quartz reefs. Strike approx. N.–S. (usually NNW.–SSE.)		
	Mainly sandstones		Mainly slates
Topography	Low ridges aligned approx. N.–S. Ridge crests and sidespurs broken by minor spurs along strike.		
av. sideslopes	Convex crests and upper slopes 5–10°	Elevations 600–800' Concave-linear lower slopes 2–4°	Alluvial-colluvial swales 1–2°
Soil key features	brownish, gradational shallow soils, stony loam surfaces	reddish duplex soils, hard setting gravelly loam surfaces	Yellowish duplex soils, clay loam surfaces, high macroporosity
av. depth (ft.)	1·0	1·5–2·5	3–6
structure			
Vegetation association	woodland E. macrorrhyncha–E. polyanthemos	woodland E. leucoxylon–E. hemiphloia	woodland E. hemiphloia–E. leucoxylon–E. melliodora
Hazards	severe sheeting	mod. sheeting	severe gullying, severe salting
uncleared Most suitable land use cleared	Forestry, conservation of flora and fauna, recreation, retention of timber as protection against erosion and salting. Grazing of deep-rooted species on all components. Return to trees and shrubs on component 1?		
Land use class where cleared	4a, 6	4a	4a
Rec. pastures lb/ac.	1½ Yarloop, 1½ Woogenellup or Bacchus Marsh, 1½ phalaris		As left plus lucerne as an alternative
Rec. fertilizers cwt/ac.	Establishment 2 of 50–50 lime-molybdated superphosphate, maintenance 1 super per year.		As left but no lime
Potential of land unit	Grazing–2 dry sheep/acre. Yet to be estimated-cropping (low), honey ?, minerals ? forestry (low), recreation (high), water supply (low), conservation of flora and fauna (high)		

Figure 24.15: The Kimbolton land unit

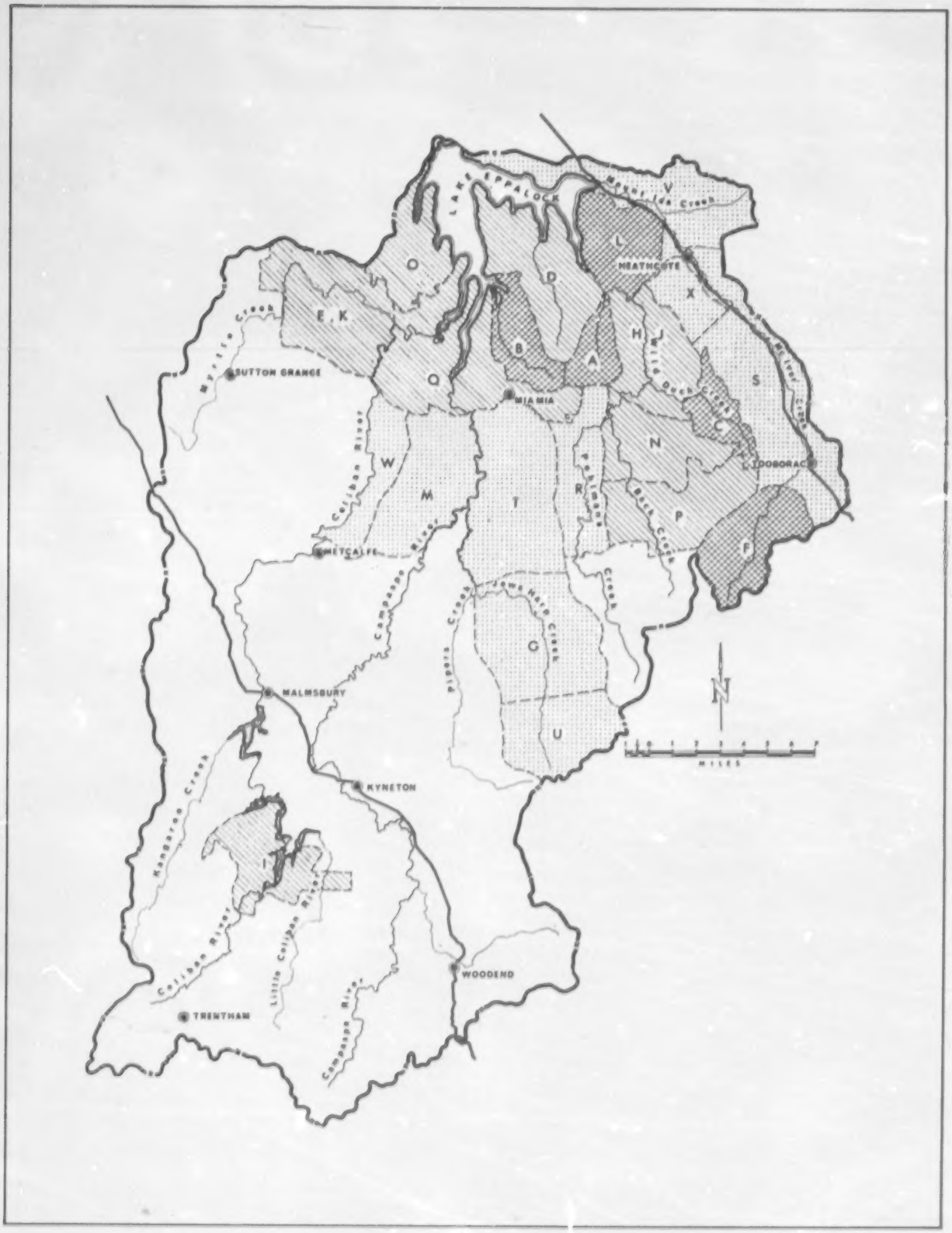


Figure 24.16: Eppalock Catchment project (see figure 24.17 for key)

Code	Name of Subcatchment	Area	Number of Properties	Year Works Commenced	Finished
		(acres)			
A	Goodalls Creek	4,340	10	1960	1967
B	Native Dog Creek	5,250	11	1961	1967
C	Dairy Creek	5,120	7	1961	1968
D	Meadow Valley Creek	12,480	12	1961	..
E	Myrtle Creek No. 1	5,570	6	1962	..
F	Tooborac Granites	9,980	17	1962	1969
G	Jews Harp Creek No. 1	12,160	14	1967	..
H	Spring Flat No. 1	3,330	8	1962	1969
I	Coliban–Lauriston	5,310	6	1965	..
J	Spring Flat No. 2	6,590	17	1962	1969
K	Myrtle Creek No. 2	5,890	7	1963	..
L	One Eye Forest	7,100	9	1963	1968
M	Back Creek	11,200	23	1968	..
N	Mountain Creek	7,100	10	1964	..
O	Kimbolton Forest	9,470	3	1963	1970
P	Pohlman's Creek No. 1	10,430	17	1965	..
Q	Redesdale–Mia Mia	12,670	32	1965	..
R	Pohlman's Creek No. 2	9,220	16	1966	..
S	McIvor Creek	14,720	42	1966	..
T	Watch Box	15,800	23	1969	..
U	Jews Harp Creek No. 2	10,820	18	1969	..
V	Mount Ida Creek	11,460	31	1969	..
W	Metcalfe North	6,080	12	1969	..
X	Argyll	2,620	22	1968	..
	TOTALS	204,710 320 sq. m.	373	..	..

Figure 24.17: Key to figure 24.16

Figure 24.18: What was the purpose of this structure (photographed at time of installation)?

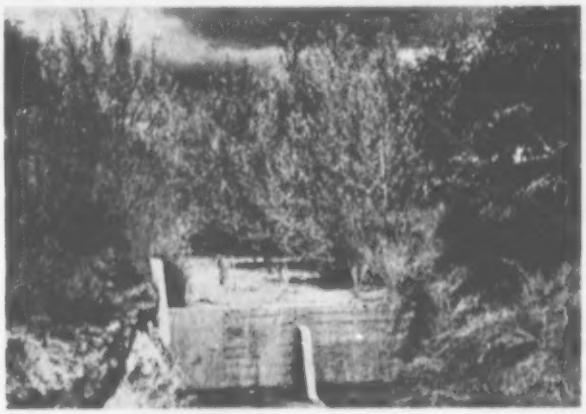


Figure 24.19: The same structure after years of operation. Has it succeeded?

Table 24.6: Pasture improvement and production on property A, 1960–70

Year	Area chisel-seeded	Superphosphate in tons	Stock carried		Wool production		
			Sheep	Lambs	Bales	Sheep (lb)	Lambs (lb)
1960	—	—	587	166	17	4 910	170
1961	175	17·5*	570	145	16	4 650	180
1962	185	36·0†	615	170	21	6 020	200
1963	88	45·0†	640	185	23	6 650	250
1964	165	50·5†	745	200	22	6 539	230
1965	158	62·0†	1 046	211	31	8 396	392
1966	26	33·0†	873	296	30	8 893	622
1967	—	40·0‡	1 140	440	39	10 248	741
1968	—	40·0‡	1 567	206	51	13 788	685
1969	—	40·0‡	1 784	—	73	21 900	—
1970	—	—	1 760	—	81	21 440	—

* Lime : super and molybdenum only

† Includes lime : super and molybdenum plus straight super

‡ Superphosphate only: maintenance top dressing

A. No topdressing had been done prior to 1960. [Table 24.7] shows how pasture improvement was executed and its reflection in production.

Table 24.7: Pasture improvement and production on property B, 1962–70

Year	Area chisel-seeded	Fertiliser in tons	Stock carried (wethers only)	Wool production (lb)
1962	137	7*	570	7 388
1963	203	21·5†	592	8 179
1964	99	30·0†	718	8 543
1965	88	26·5†	852	12 671
1966	49	58·5†	1 080	14 182
1967	—	39·0‡	1 206	14 603
1968	—	39·0‡	1 243	15 302
1969	—	39·0‡	1 375	19 545
1970	—	39·0‡	1 604	23 937

* Lime : superphosphate and molybdenum only
† Includes lime : super and molybdenum
‡ Superphosphate only

The stock number shown as 1604 sheep at shearing time in 1970 had increased to 1932 in 1972. It is still quite inadequate to cope with the tremendous amount of feed in the paddocks which, from the point of view of quantity as well as quality, would be better suited for cattle than sheep.

Even at the present carrying rate of 2.5 sheep/acre this property is definitely understocked and could, without any further improvement, comfortably carry 3 sheep/acre or better.

One improved paddock was left ungrazed for about fifteen months simply because there were insufficient stock to graze it.

Over-cautiousness, and the high price of stock at the time when it should have been bought, have prevented the landholder from reaping the full benefit of his improvement. The inadequacy of fences and of the existing stock water supply, and the lack of experience, have so far prevented the introduction of cattle.

These are two examples of how pasture improvement by chisel seeding have improved production. There are many others.

In planning such improvements the Soil Conservation Authority follows the procedure given below.

Planning procedure

With the aid of specially flown aerial photographs land feature drawings are prepared on a grid basis.

These drawings at the scale of 1 inch = 10 chains show such features as roads, streams, erosion, timber and fencing. It is on to these drawings that the proposed soil conservation plan is superimposed.

However, the foundation to any sound conservation plan is a careful study of all relevant background data. Such background data includes:

- *Geology*—Provides useful information about the likely potential of soils formed over particular parent materials.
- *Topography* (shape, slopes, aspects)—Frequently places a limit on what use can be made of the land. May be modified, for instance by the use of a variety of contour works, to make safe a certain type of land use which otherwise may not be.
- *Climate*—Cannot be changed but understanding it helps to ensure the greatest advantage is taken.
- *Soils*—Both the physical and chemical composition of the soils and the distribution of these soils are studied. Consideration is given to how these might be modified and improved.
- *Natural vegetation*—Can give a guide to production potential and most suitable forms of land use.
- *Past and present land use*—Influences the present condition of an area and provides information as to whether such forms of land use are safe or are realizing the full potential of the area.
- *Incidence, type and severity of soil erosion*—Gives information as to how wrong past land use may have been.

By a study of such background information, areas can be classified into units of similarity and differences, thus producing a Land Class Plan.

The Land Class Plan maps the various parcels of land which can be grouped safely or need to be separated to enable special management and use.

The Land Class Plan is the foundation upon which the Conservation Plan is drawn up.

Land Classes used by the Authority are:

1. Land suitable for cropping without the need for erosion control measures.
2. Land suited for cropping, but in need of erosion control measures—
   (a) no mechanical works are needed, but broad rotations (e.g. pasture for at least 3 years out of 5) and/or special cultivation practices (e.g. stubble mulch) are required.
   (b) in need of the use of the contour principle, namely contour cultivation alone or together with closed banks or graded banks and waterways.
3. Land suitable for grazing without the need for erosion control measures. (Not suitable for cropping because of unfavourable soils, topography, surface conditions, or climate; for example, on the stony rises stone outcrops prohibit cultivation. Some heavy soils are not suited to cropping because of climate limitations.)
4. Land suitable for grazing but in need of erosion control measures—
   (a) can be ploughed for pasture improvement and can be contour banked, furrowed or ripped.
   (b) cannot be ploughed but can be surface worked for pasture improvement and can be contour furrowed or ripped.
5. Land suitable for strictly controlled grazing where no mechanical erosion control measures can be undertaken and a vegetative cover must be carefully maintained.
6. Land not suitable for agricultural production because of roughness, stoniness, wetness, dryness, infertility or extreme erosion hazard.

The Land Classes most commonly encountered in the Eppalock Project are 2b, 4a, 4b and 5 and the greatest potential for improvement is found in Land Classes 4a and 4b.

The first stage in planning is to produce a Land Class overlay transparency which when superimposed on the base feature drawing provides vital basic information in deciding desirable fence location and the areas which might be sown to improved pasture either by contour chisel seeding (4b land) or perhaps by more orthodox means (2b and 4a land).

This land classing system was the one used by S.C.A. officers in preparing the plan for the farm in study 5. Try to land class your school's area or any other suitable area of land. If you visit a farm you could class the land—is the farmer farming correctly, in your view?

Soils are only part of the total drainage system. If people change one part of the system, as the first farmers of the Eppalock Catchment did in removing the tree cover, other parts of the system will also change, often with unfortunate effects throughout the total system.

Draw a diagram to show how the Eppalock Catchment system was changed by man, and the effects of these changes.

B: The river subsystem in a drainage basin

Examine figure 10.18 on page 88. Many drainage basins can be found in this area. Identify a small one, and trace the margins of the basin and the streams within it. Your tracing should resemble figure 24.20.

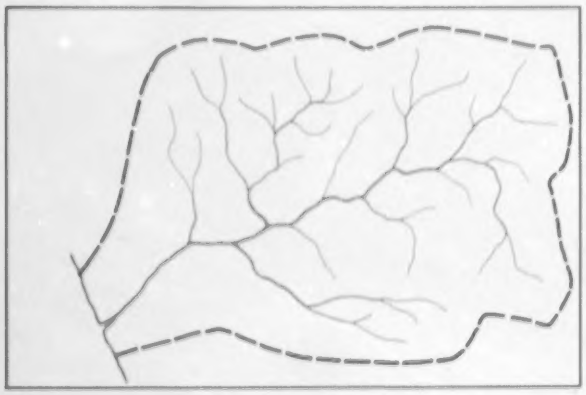


Figure 24.20: Sample drainage basin

Compare the drainage basin that you selected with those chosen by other students. Alternatively, trace several different drainage basins. (Your work will be improved if you find other topographic map sheets and use them as well.) In what ways do drainage basins vary?

- Are they all the same size?
- Are they all the same shape?
- Do they all have the same number of streams?
- Are all streams of the same length?

There are some useful ways to describe drainage basins. For example, you could find the area of the basin in square kilometres. However, an easier way of describing the basin is to refer to the *stream order* reached by the drainage network.

All drainage networks begin with *first-order* streams. Where two first-order streams join, a *second-order* stream is formed. Where two second-order streams join, a *third-order* stream begins, and so on. If a stream joins another stream of higher order, then the stream order does not change; for example, if a first-order stream joins a second-order stream, the stream remains a second-order stream (see figure 24.21).

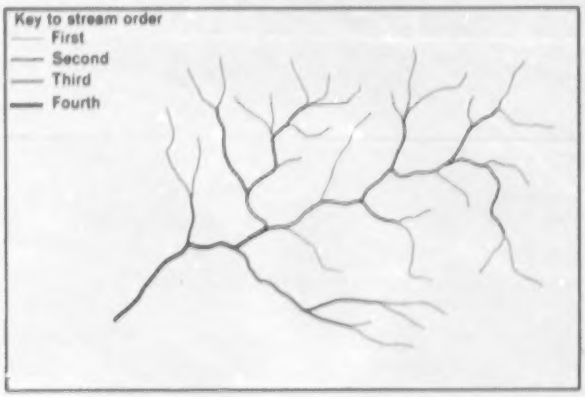


Figure 24.21: Sample drainage basin with rankings of stream order

Refer again to your sketch or sketches and carefully label each stream segment as in figure 24.21. In this example, the drainage basin is described as a fourth-order drainage basin. Naturally, the stream order attained by a stream network may vary. The Mississippi river basin is a tenth-order drainage basin (based on maps at the scale of 1:62 500).

Another useful way of describing a drainage basin is to find its *drainage density*. Some basins seem to have a lot of streams. Other basins of the same size may have fewer streams. We could say, then, that the basin in figure 24.22 has a greater drainage density than the basin in figure 24.23.

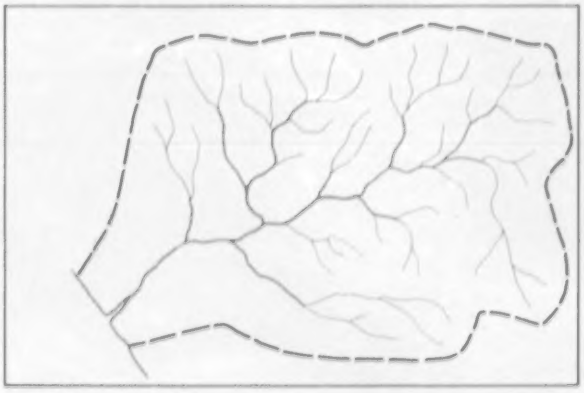


Figure 24.22

Figure 24.23

Drainage density can be calculated by finding the total length of all streams in the basin, and then dividing by the area of the basin:

$$\text{drainage density} = \frac{\text{total length of all streams (km)}}{\text{area of basin (km}^2\text{)}}$$

In some areas, such as the Badlands of South Dakota, drainage densities of 125 to 310 are common. This means that for every square kilometre there are 125–310 kilometres of stream channel. Look at the different drainage basins you have traced, in relation to the features on the base topographic maps. Why do you think some areas have high drainage densities and other areas have low drainage densities?

You may find evidence in photographs of drainage basins. Visits to various parts of the local area may also be helpful. You could also set up a series of experiments, as follows.

Build up two mounds of earth, one of clay loam and one of sandy material. Spray a fine jet of water over both mounds. Take note of the extent of erosion and the drainage density that develops. Does the kind of material affect drainage density?

Repeat the experiment, this time with two mounds of firm material (such as clay loam), and using a more intensive spray of water. Does intensity of rainfall bring about a different drainage density?

Finally, restore the two identical mounds and cover one with grass sod. What effect does this have on drainage density? Can you think of additional tests to find whether or not there are other factors that may cause differences in drainage density?

In what ways are the drainage basins you have drawn similar?

Do they all have the same shape? Do they all have more first-order streams than streams in other orders? Indeed, is there a ratio between the number of streams in each order? You could test this idea by using table 24.8.

Table 24.8: Sample table to show analysis of basin

Stream order	Number of streams	Ratio of streams in next higher order to streams in next lower order
1		
2		
3		
4		
etc.		

Are first-order streams longer or shorter than second-order streams?

Do first-order streams flow on steeper or gentler slopes than higher order streams?

Can you think of some other questions that you could ask in order to find similarities or differences between drainage basins?

THE TONE RIVER

The Tone River is one of Japan's largest rivers. It has the largest catchment area (15 759 square kilometres), and is 322 kilometres long (third longest). It attains a stream order of about 7.

Figure 24.24: The Tone River basin

Find the Tone River on an atlas map. How does the Tone compare in length with major Australian rivers?

About 55 per cent of the Tone basin is forest, grass and highland, and about 1·7 per cent is barren and devastated by frequent landslides. When there is a flood, there are tremendous yields of sand and gravel. In 1949, during typhoon Catherine, avalanches occurred that inflicted extensive damage on Kiryu and Ashikaga cities. At that time the banks of the Tone were broken in fifteen places and much arable land was flooded and littered with sand and gravel. Why does such destruction occur? What can be done to prevent it?

Examine table 24.9. What is the relationship between maximum and minimum flow for Japanese rivers and the other rivers listed?

Table 24.9: Maximum and minimum flows of various rivers

Name of river	Name of country	Catchment area (km^2)	Maximum discharge ($m^3 s^{-1}$)	Minimum discharge ($m^3 s^{-1}$)
Tone	Japan	5 150	17 000	46*
Yodo	,,	7 281	8 650	74
Kiso	,,	4 866	14 000	49
Shinano	,,	9 843	9 000	69*
Kitakami	,,	7 060	9 000	63*
Chikugo	,,	1 362	8 500	6
Yoshino	,,	2 768	17 500	48*
Colorado	United States	286 500	7 000	70
Seine	France	44 300	2 330	100
Rhone	,,	50 200	5 900	340
Rhine	Switzerland	34 500	5 000	360
Yellow	China	715 184	25 000	245
Yangtze	,,	125 000	73 300	3 300
Mekong	Cambodia	662 000	60 000	1 700
Ganges	India	905 000	60 700	1 750

*Becomes less than this figure in irrigation seasons

What relationship is there between catchment area and discharge for Japanese rivers and the other rivers listed?

Why do you think such differences exist between Japanese rivers and rivers in other countries?

River control has long been a problem in Japan. Rivers are short and swift, and many flow uncontrolled to the sea. Most Japanese rivers have flood discharges for only a short period, but they can be very destructive at such times. Since 1868, the latest technology has been employed in river control.

Many artificial levees have been built. (What is a levee?) However, such levees did not improve the overall situation very much. First, in the areas protected by levees people were for the first time able to farm the floodplain; this often produced a demand and need for even more land conservation work. Second, the discharge of the river was increased because water that once flowed over the floodplain was now confined within the levees. Thus, the likelihood of destructive floods downstream increased greatly. Third, artificial levees provide only temporary relief as the gravels and sands continually build up the river bed. There are some rivers in Japan in which the river bed is actually higher than the area outside the levees (see figure 24.25). The Japanese call such rivers *tenjo-gawa*, or 'a river flowing above the roofs'. Obviously, there are economic and technical limits to the artificial extension of levee banks. The cost of building such levees becomes very great, and the damage done by floods if the levees are broken is enormous.

Multi-purpose dams have become popular as a means of river control, especially to:

- detain flood water and so prevent destruction
- ensure a reliable water supply for domestic and industrial use
- ensure a supply of electric power to meet the growing demand
- ensure water for irrigation in the dry season and even in drought years
- support the extension of food production areas and of yields.

In considering proposals to build dams, planners have to contend with:

- the lack of suitable sites for large dams. The steep slopes mean that there are few areas where large amounts of water can be stored by a dam. River-bed gradients are often steep, and river gorges are in many cases too narrow to make it economic to build a dam. Those sites that are suitable are often also suitable for agriculture.
- the danger of the collapse of mountain slopes
- silting up of dams. Many factors contribute to the flow of sediment from mountains:
  (a) the nature of the rocks. Much of Japan is new volcanic rock and other fragile material. Many of the older rocks are vulnerable to weathering
  (b) steep slopes
  (c) bouts of very heavy rainfall as in typhoons
  (d) earthquakes—Japan has about 1500 registered earthquakes every year.
  (e) the cultivation of mountain slopes.

If possible, visit an expanse of natural bushland in an area receiving more than 850 millimetres of rain per annum. Compare the movement of water through this area with the movement of water through a relatively bare area of land. Make notes on the following:

- velocity of flow
- erosion type(s)
- amount of material apparently eroded
- amount of moisture in soil (a soil auger could be valuable in finding depth of moisture)
- likely evapotranspiration from the area
- cleanliness or quality of water.

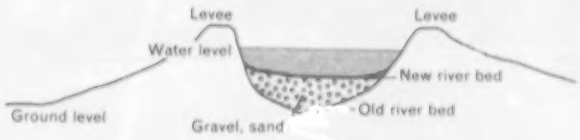


Figure 24.25

Sediment flows can severely reduce the water storage capacity of dams (table 24.10 and figure 24.26). The dams are less effective, then, as flood controls.

Refer to figures 24.27–24.29. What changes have taken place? What are the advantages of having steep hillsides in forest, or at least well vegetated?

Figure 24.26: Administrative districts of Japan

Table 24.10: Annual sediment volume deposited in reservoirs, by district

District	Number of reservoirs	Volume (cubic metres)		
		Maximum	Minimum	Average
Hokkaido	3	26	11	16
Tohoku	7	618	109	299
Kanto	3	542	28	261
Chubu	9	3030	90	591
Kinki	3	297	36	180
Chugoku	5	376	51	270
Shikoku	4	276	117	210
Kyushu	5	1851	85	578

Compose a map of the data in table 24.10 to show whether or not some areas probably yield more sediment than others. Attempt to explain the spatial variations you detect. This may involve some research. For example, is there a relationship between the distribution of volcanoes (figure 24.30) and sediment yield to reservoirs? What else might explain the different sediment yields from place to place?

How can such sediment yield be controlled? In Japan *sabo* dams, or sand and gravel dams, are another common means of stabilising land. (Refer to figures 24.31–24.33.) Such work began in 1936 for the Tone river system.

A final means of controlling floods is the *floodway*, protecting land towards the mouth of the river. (Find out how a floodway works.) On the Tone River, a floodway was built in 1654 to direct water from Tokyo Bay to the Sea of Kashima near Choshi city. This basic diversion has been maintained and improved over the years.

Figure 24.27: Hillside work in progress, 1933

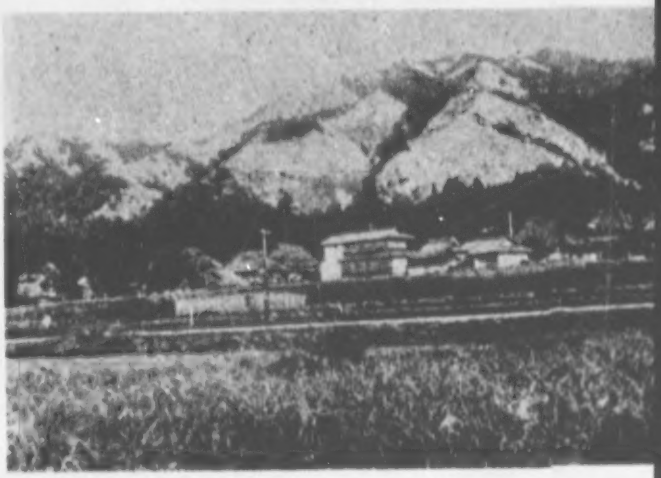


Figure 24.28: The same area in 1935. Look carefully at the faint horizontal lines on the hillsides. What might these indicate?

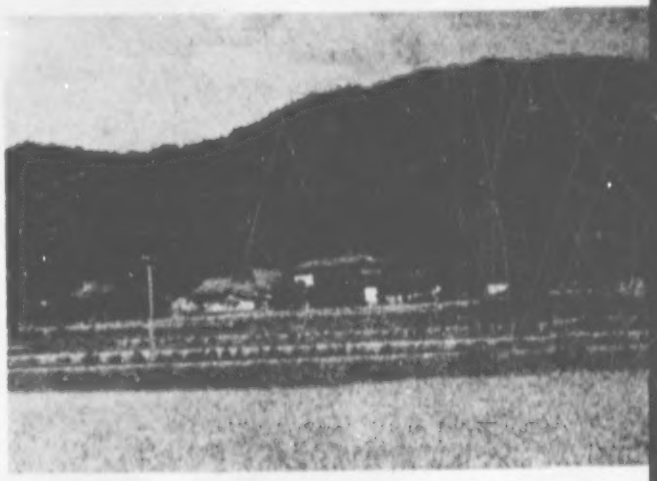


Figure 24.29: The same area in 1954

Figure 24.30: Volcanic regions in Japan

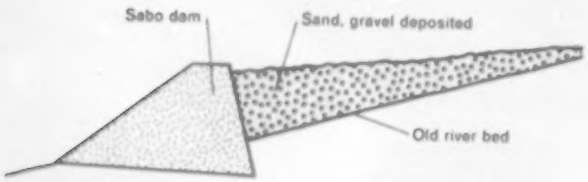


Figure 24.31

Figure 24.32

*Figures 24.32 and 24.33: **Sabo** sand storage dams. In what ways do they resemble the structure shown in figures 24.18 and 24.19?*

Even the floodways may not offer complete protection from disaster in some areas. Read the following extracts from the *Tokyo Municipal News*. The first is dated October–November 1970, while the second is dated January 1971 and is by Professor Miyabe of Komazawa University, Tokyo. (Allow for the difficulties experienced by the Japanese translator.)

Land subsidence spreads

The Metropolitan Institute of Civil Engineering, August 22, published its report on a land subsidence survey made during 1969. The report says that the degree of land subsidence in Tokyo last year was somewhat lower on the whole than in 1968, which saw the worst record, but the low-lying eastern district still met with heavy land subsidence as deep as 20 centimetres in a certain place and had more places which came to lie below the sea level.

The survey of land subsidence at present is conducted through the levelling at 431 points and the land subsidence observation wells at 21 points. The 1969 survey reveals that the areas which sank one centimetre or more deep have spread over 294.6 square kilometres, or more than half the ward area. What is called the zero-metre areas which lie lower than the sea even at ebb tide have swept over 29.1 square kilometres with an addition of 1 to 2 square kilometres every year. The areas which become lower than the sea at high tide have extended over 123.7 square kilometres, more than one-fifth of the ward area. In the eastern district, always afflicted with sharp land subsidence, there is a place which underwent 4 metres or more land subsidence for 50 years past.

The foregoing aggravated state of land subsidence will naturally bring about a severe flood disaster when a raging typhoon or a great earthquake hits the subsided areas. The report gives warning thus and concludes that unless the pumping-up of underground water, which is the major

cause of land subsidence, is more strictly controlled, aside from anti-flood measures, a vital question will be brought on the inhabitants of the subsided areas.

The problems of land subsidence

The land subsidence has been developing in the low land of Tokyo these several tens of years and, as a result, the land lower than the low tide level has become apparent in the eastern part of the low land of Tokyo. Such a low land is named 'zero-metre area'.

In the zero-metre area and the adjoining zones, the lowness of the land level as well as the land subsidence still taking place have badly influenced the industrial activities and daily lives of inhabitants there: that is, the zero-metre area is not only subjected to constant danger of invasion of water due to flood and high tide, but also the transportation by land and by water are much disturbed by the lowering of the land surface relative to the water level and the structures are apprehended to be destructed due to differential subsidence.

In order to protect the land from danger of invasion of water at the time of high tide, high wall of anti-highwater bank was constructed around the land under consideration. The land subsidence, however, is going on in this area at the rate of 10 to 20 centimetres per year, and the bank is also lowered as much as the amount of land subsidence, so that it would become of little avail in protecting the land from influxes of high water within several years.

In addition, the differential subsidence will gradually develop hair cracks within the body of the bank, which perhaps may reduce the resistivity of the bank against the shocks due to high water waves and those due to earthquakes. There also are a number of buried structures; that is, water and gas pipes, sewer pipes, electric transmission lines and so on, which are buried within the depths of a few metres from the ground surface. The advance of land subsidence, especially the differential subsidence, may induce certain stresses within the bodies of these pipes, which may sometimes cause their disruptive destruction and occasionally explosions.

Those mentioned above may be matters to disturb the industrial and human activities in the area under consideration. Therefore, it is necessary to control the advancement of land subsidence in order to protect industrial and human activities in this area, from the above mentioned disturbances.

Read the following article by R. G. Downes, formerly chairman of the Soil Conservation Authority of Victoria. It sums up a lot of the ideas contained in studies 23 and 24. What additional aspects of drainage basins does it discuss? Redraw figure 23.1, making a diagram of *all* aspects of the drainage system.

Why water supply catchments must be managed

Modern industrial society depends on large supplies of good-quality water. In places like England and the United States of America, which are well-endowed with water, there is concern at the rising rate of water consumption in relation to total resources. For this reason, there is growing interest in studying both the factors which affect the water yield from catchments and the extent to which it is important to control the kind of land use being practised.

In dry countries, like Australia, there is an even greater need to promote these kinds of investigations, and to ensure the proper care and management of catchments, so that their value as water producing areas is not impaired.

A catchment is a good one if it provides a high percentage of the total water falling on it as clean water yield, and the nearer the yield approaches a uniform rate, the more useful the water becomes. Except in some very wet areas, these qualities are not often attainable, but they represent objectives to be pursued in the management of catchments.

Management is the manipulation or alteration of conditions to achieve certain objectives. In the management of a water supply catchment, we must be sure that our objectives are correct for the particular circumstances. For example, in some catchments, the uniform rate of yield is the important characteristic which must be safeguarded, while in others a reduction of sediment load, even if it means a reduced water yield, may be the most desirable objective. In pursuing the objectives, manipulation must be based on an understanding of basic scientific principles. This requires a knowledge of how catchments work and how the various operating factors affect the fate of water which falls on the catchment as rain or snow. . . .

In catchments well covered with vegetation, rain or snow is intercepted and rarely falls directly on the surface of the soil. When the vegetation is thoroughly wet, water may drip from leaves or branches, or it may flow down the branches and stems to reach the soil. The vegetation itself is capable of holding a considerable amount of moisture, which never reaches the soil but is evaporated from the surfaces of the leaves and trunks and from the ground surface cover of litter or grass. This water is a total loss so far as the water yield of the catchment is concerned. However, it has some value to the catchment because it must be evaporated before plants begin to transpire water and so reduce the soil moisture storage. Furthermore, water being evaporated from the trunks and bark of the vegetation produces a shroud of high humidity which reduces the rate of transpiration of the vegetation for some time.

So rain on a catchment may fall on vegetation and be evaporated soon after the rain ceases. It may fall through the vegetative canopy to the surface litter or surface vegetation and be evaporated more slowly; or it may, by means of stem flow or drip or even by direct path, reach the surface of the soil.

On reaching the surface of the soil, water has two possible courses. If the water is reaching the soil at a rate slower than the capacity of the soil to absorb it, then all the water will soak into the soil until it becomes saturated. When the soil is saturated, or water is reaching the surface at a greater rate than the ability of the soil to absorb it, water will accumulate on the surface and, after a time, begin to flow to lower parts of the catchment. Whether or not surface flow occurs depends on the slope and the nature of the surface cover. If the surface of the soil is covered by a deep litter or a dense cover of grass, a considerable amount of free water can accumulate above the surface of the soil without much overland flow of water occurring. Under

these conditions, even when overland flow begins, its passage is relatively slow.

When water enters the soil, it at first merely adds to the soil moisture storage until the soil reaches its field capacity and is unable to hold further moisture against the force of gravity. At this moisture content, water moves downward through the soil bringing successive layers up to the field capacity, and ultimately free water percolates beyond the soil itself down into the country rock to deep underground aquifers. On sloping land, there may be some lateral movement or seepage of water down slope. This occurs particularly when the soils have less permeable subsoils or rock is close to the surface. When the lower portions of the soil are unable to absorb water as rapidly as the surface, the surface soils become saturated and while rain is falling movement of water will be mainly above ground, but seepage flow will continue below ground after the rain has ceased.

In the periods between rains, the soils lose water by supplying the needs of plants which transpire it back to the atmosphere. But the soil can be dried out by plants only to a certain moisture content known as wilting point, at which the water remaining in the soil is unavailable to them. Furthermore, as the soil will only lose moisture to plants from the zones exploited by roots, the nature of the vegetative cover, and the depth to which its roots penetrate and extract moisture, are important characteristics of catchments.

Water yield from the catchment comes mainly from surface flow, either directly across the surface of the catchment or from springs and streams fed by seepage. Water percolating deep underground may be lost altogether from the catchment itself, particularly in small catchments. However, in large catchments it may be recovered as spring or stream flow lower down and so contribute to the water yield. Water lost to the deep underground aquifers may be recoverable from artesian and sub-artesian bores at some distance from the catchment.

If a catchment has characteristics in which a big proportion of the water yield is from overland flow, then the yield will be obtained quickly after each occurrence of rain, and, if these catchments are used for water supply purposes, storages are required so that water is available between rains. If the overland flow is negligible and most of the water soaks into the soil and the yield of the catchment is the result of seepage water reappearing at the surface as streams some considerable time after the rain, then there is a more uniform rate of water yield. The flow only rises when rain is actually falling on the catchment and only becomes slightly less towards the end of dry periods.

In catchments where a considerable amount of yield occurs as surface flow, other hazards are encountered. Water flowing quickly over the surface of the soil causes erosion, and so the quality of the water may deteriorate considerably because of the silt load, and since in this kind of catchment storage is necessary there is a further danger of the storage being reduced in capacity by the silt which will be deposited in it.

The . . . catchment is a balanced system suitable for the kinds of vegetation, soil and topography which have evolved for the prevailing climate. Changes of land use can alter this balance, often permanently, and so create conditions which lead to serious deterioration of the catchment. Any variations of land use which involve a big change in the character of the vegetation, either in the amount of cover and protection it gives to the soil, or in the nature of the root system and depth in the soil from which roots draw moisture, will cause changes in the relationship between rainfall and run-off, and also in the character of the distribution of the flow throughout the year. Any form of land use which leaves the soil open to the pounding action of rain drops or enables the destruction of the structure of the soil and its capacity to absorb water will also [have serious effects]. Change . . . has already occurred in some catchments because of alterations in land use and problems such as sheet and gully erosion, tunnelling, salting and reduced summer flow have emerged.

There is an urgent need for the study of all aspects of catchments to understand the critical factors determining the relation between rainfall and run-off. It may then be possible to plan and test changes of management which may achieve a high percentage yield of clean water or a more satisfactory distribution throughout the year. In the meantime, the catchments must be safeguarded from any damage which will affect their capacity to produce water.

The prime objective of catchment management in Australia must be water production, and in some small vital water-supply catchments it may be necessary to restrict all other forms of land use. However, in large catchments, multiple use is a most desirable objective and should be possible of attainment without detriment to water production from them.

Victoria's Resources, June–August 1968, pp. 13–14, 27

25

Victorian farmers use the drainage basin for irrigation

Figures 25.1 and 25.2 show the rainfall isohyets and water run-off for Victoria. What do they indicate about the distribution of water availability in Victoria? Irrigation is essential for certain types of agricultural production, as you saw in study 4.

Figure 25.1: Rainfall isohyets, Victoria (mm)

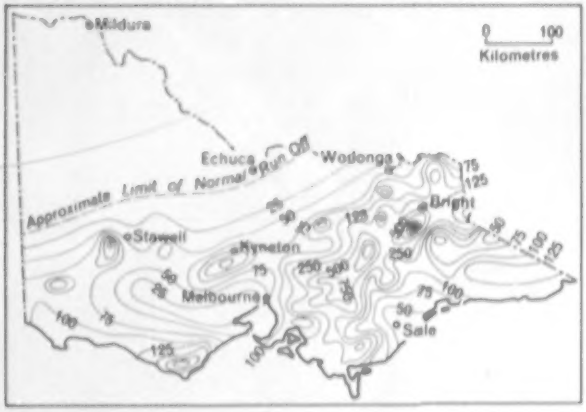


Figure 25.2: Victoria's water run-off pattern (mm)

The Goulburn water supply system (figure 25.3) covers a large area, as can be seen from table 25.1.

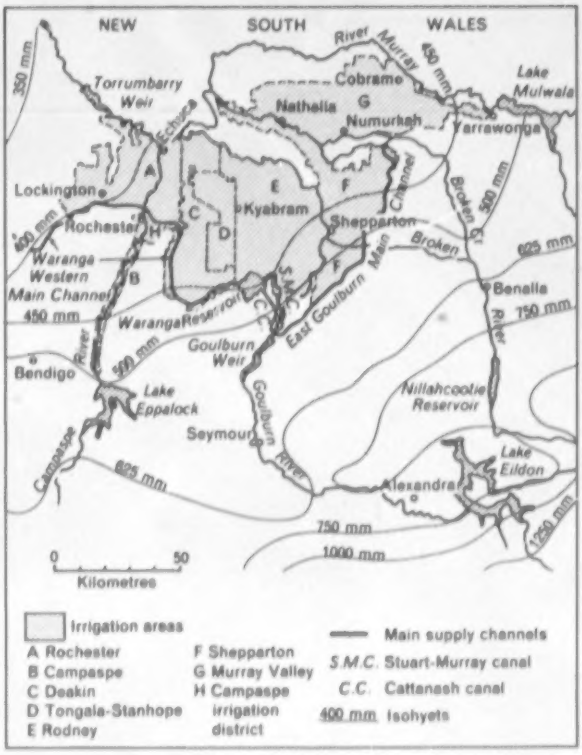


Figure 25.3: The Goulburn water supply system

Table 25.1: Goulburn water supply system, 1968–69

District	Area (hectares)	
	Total holdings	Area irrigated
A. Rochester	74 690	33 293
B. Campaspe	7 995	1 555
C. Deakin	64 579	10 910
D. Tongala-Stanhope	30 910	23 975
E. Rodney	109 718	65 857
F. Shepparton	90 923	36 796
G. Murray Valley	122 263	50 331
	501 178	222 717

As run-off is low in the northern part of Victoria the water in rivers coming from outside the area must be dammed to provide an irrigation supply.

Lake Eildon (figure 25.4), the main storage for the system, has a capacity of 3 400 000 000 cubic metres. It is estimated that the reservoirs of the State Rivers and Water Supply Commission lose more water by evaporation each year than the total consumed by Victorian cities and towns. To minimise evaporation, engineers prefer to build narrow, deep reservoirs rather than storages with little depth and large water surfaces. Examine figure 25.4; to what extent does Lake Eildon fulfil this requirement? In figure 25.4 you can see the normal outlet of the dam on the far side of the dam wall, and the overflow in the foreground. Just below the dam wall at the head of the normal outlet there is a hydroelectric power station.

Figure 25.4: Lake Eildon, near Alexandra, is Victoria's largest reservoir. Water released from the storage flows down the Goulburn River 250 kilometres to Goulburn Weir, where it is diverted to lands lying on both sides of the river

After water has been released from Lake Eildon it flows down the Goulburn River. Examine figures 25.3 and 25.4. Of what significance is the Goulburn Weir in the water supply system? Examine the location of the Spivey farm discussed in study 4. Which of the two main channels would serve this farm?

The water flows through the two major channels, which run on a very gentle incline. What effect does the location of the two channels have on the distribution of the irrigation areas? Why is this? The two major channels are lined with concrete to prevent seepage. Water is then passed into smaller channels, from which the farmer draws his irrigation supply.

As you saw in study 4, the amount of water drawn by a farmer is gauged by a Dethridge meter (figures 4.10 and 25.5). This simple, cheap device, almost universally used in Victoria for measuring irrigation water supplied to farms from S.R.W.S.C. channels, was designed by J. S. Dethridge in 1910. (He was then chief engineer of the S.R.W.S.C., and was later to become its commissioner.)

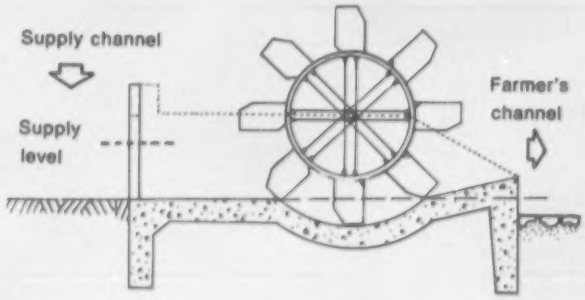


Figure 25.5: Side view of Dethridge meter and its emplacement

The meter consists of an undershot water wheel turned by the discharge water passing through its concrete emplacement. The meter gives a positive measurement of the volume of water discharged, recorded directly by a revolution counter driven by the wheel axle. Under normal working conditions, accuracy of measurement is within 5 per cent.

On the farm, the water may be run across the ground in open channels, or underground in pipes. What method does Mr Spivey use? The water is then used to irrigate the plants. There are three methods of watering. What are these methods, and what do you think are the advantages and disadvantages of each?

Mr Spivey uses flood irrigation. Two different layouts for flood irrigation are shown diagrammatically in figure 25.6:

Border check layout

The border check layout consists of evenly spaced parallel banks (check banks), which run down the slope along each line of trees (see figure 4.13). At 'Tranby Croft', Mr Spivey's farm, this layout is used for the northern two-thirds of the block. Water is conveyed to the bays from the irrigation supply channels at the head, and flows down the length of the bays to drainage ditches that remove any excess water. The direction of water flow is shown in figure 4.12.

Basin layout

In basin layouts, parallel check banks run both down the slope along the line of trees, and across the slope at every 5 centimetre fall in elevation, thus forming small basins. This layout is used for the south-western section of the orchard. As outlined in study 4, the irrigation water is conveyed to these basins by an underground pipeline and released through small upright outlets (risers).

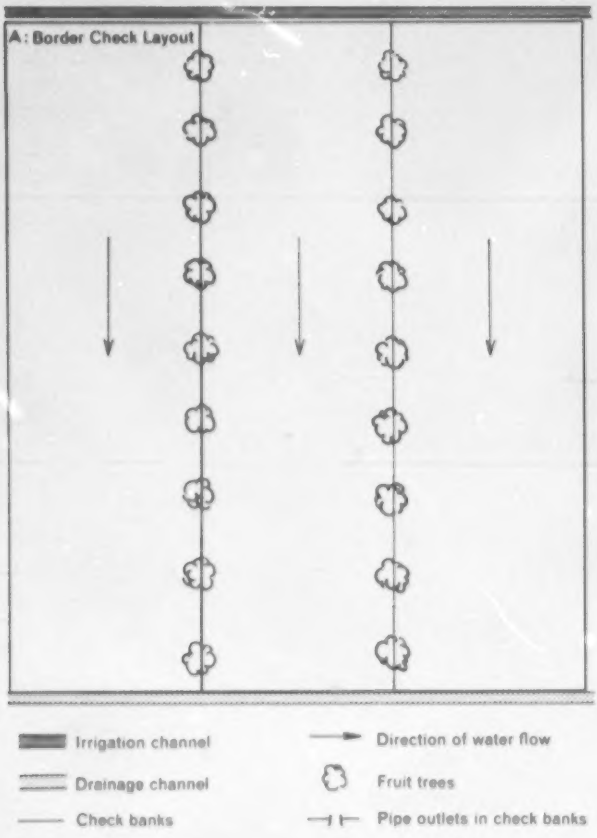


Figure 25.6: Two layouts for flood irrigation

Another type of irrigation is *trickle* or *drip* irrigation. With trickle irrigation, water is dripped continuously or intermittently into a restricted root zone around the plant. This method is still largely experimental in Victoria, having been introduced from Israel in 1968. What might be the advantages and difficulties of trickle irrigation? Has it been a successful method of irrigation in Israel?

One of the problems of pouring water on to the soil in flood or channel irrigation is that the type of soil system may not be able to cope with the amount of water. If too much water is poured on, waterlogging could occur as the water table rises close to ground level, and this could affect the fruit trees.

Examine table 25.2 and compare it with figures 4.3 and 4.7.

Table 25.2: Tolerance of fruit trees to waterlogging

Type	Tolerance of fruit to waterlogging
Peach	Low
Pear	High
Apricot	Moderate
Apple	Not significant

How does Mr Spivey arrange his land use in terms of these degrees of tolerance to waterlogging? Does there appear to be any connection with the types of soil? What procedures does Mr Spivey undertake to prevent waterlogging?

What is the irrigation water used for? Examine figure 25.7. What does this indicate about the

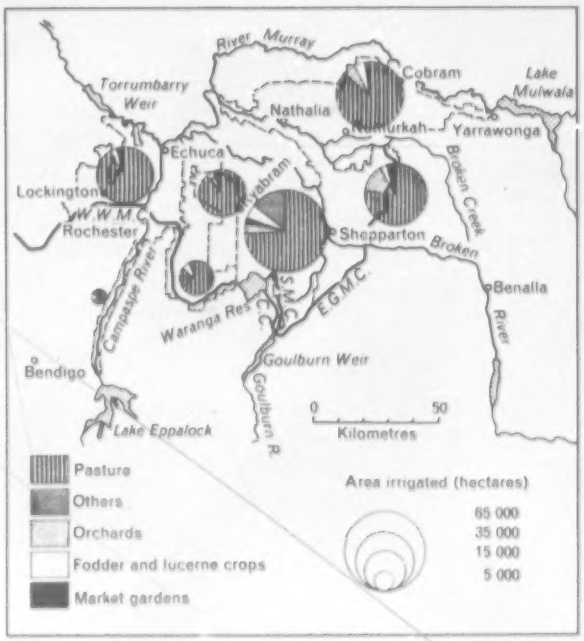


Figure 25.7: Types of land use under irrigation, 1968–69

types of land use under irrigation in the Goulburn Valley? How are the different types distributed over the area? Can you think of any reasons to explain the distribution?

Although we expect to find irrigation in areas of low rainfall, farmers who irrigate are even found in higher rainfall areas. For example, the market gardener in the south-east of the Melbourne metropolitan area (Level One, *Man and Space*, study 4) and the farmer in study 5 of this book both use irrigation. A number of farmers privately divert water from rivers for their use. A survey revealed certain facts (tables 25.3–25.8 and figure 25.8) about irrigation by these private diverters throughout Victoria.

Table 25.3: Sizes of farms where water is privately diverted

Size of farm (hectares)	Percentage of farmers
less than 20	12
20–40	10
40–80	19
80–160	22
160–325	16
325–650	11
650–975	4
> 975	6

Table 25.4: Importance of irrigation to private diverters

Percentage of all farms	Percentage of each farm	Number of waterings per annum
11	less than 5	1
47	less than 25	1 to 3
42	more than 25	4 or more

Table 25.5: Area of farm irrigated by private diversion

Irrigated land (hectares)	Percentage of farmers
Less than 8	18
8–20	37
20–40	20
40–80	12
80–120	8
> 120	5

Table 25.6: Irrigation methods used by private diverters

Type of irrigation	Percentage of farmers
Spray only	
pasture or fodder crops	29
cash crops	19
both above categories	6
Flood only	
pasture, fodder crops, cereals	30
Spray and flood	
pastures or fodder	6
Furrow	
vegetables, vines, orchards	4
Other	
combination not included	6

Table 25.7: Sources of water for private diversion

Water source	Percentage of farmers
pumped direct from river, lake or stream	68
used gravity flow from river, lake or stream	6
used river supply plus farm dams	18
tapped groundwater	8

Table 25.8: Topography of farmland of private diverters

Topography*	Percentage of farmers
Flat (slope less than 1°)	37
Moderately steep	37
Steep (slope greater than 5°)	13
Flat and moderately steep	7
Flat and steep	2
Moderately steep and steep	4

*Some farmers were irrigating very steep land, particularly in South Gippsland and the Dandenongs. Also, on several properties the irrigated land was up to 60 metres above the source of water supply.

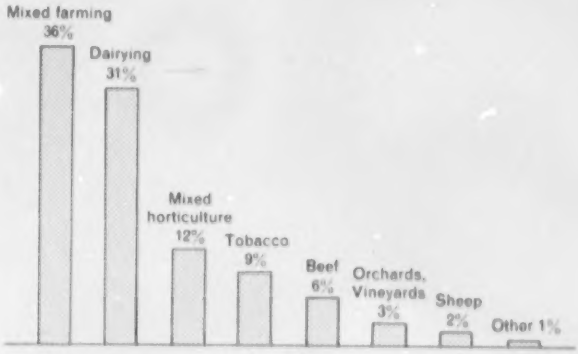


Figure 25.8: Farming enterprises of private diverters

From your examination of this data, you should have learnt something of the type of enterprises, the size of farm and the methods of irrigation of the private diverters. Now we can look more closely at their reasons for using irrigation, and whether they consider their system is profitable or not.

On what basis did these farmers choose the irrigation system in use on their farms?

Forty-three per cent had made a sound assessment of whether their irrigation system was likely to be profitable. For example, they may have set up a trial on a small area first, used experimental results, considered a range of systems used on other farms, etc.

Sixty-two per cent of the private diverters interviewed considered their system was profitable. To come to this decision they had compared returns gained with cost of extra production. Another 26 per cent thought their system was profitable, but had a doubtful basis for this decision.

These private diverters farm outside the normal irrigation areas. What differences did you notice

between these private irrigators and the system irrigators? What could be the dangers of private diversion?

A wide range of farmers use irrigation water that they divert from the normal drainage system. Although irrigation increases productivity in land use, it can have damaging effects on farming land. What precautions must farmers take before they irrigate and while they are irrigating?

Draw a diagram to show how the Goulburn irrigation system has changed the drainage system of the Goulburn catchment; include the problems irrigation can cause and the precautions farmers must take.

26

Evaluation

In Levels One and Two, this evaluation section helped you discover whether you had developed the skills that were required for each level, and the concepts that were central to the ideas in each level.

In this level, the task is more difficult. Most of the skills required in Level Three have already been tested in the evaluation sections of Levels One and Two. The basic skills—the ability to draw maps, read a map, find the patterns in a map and draw conclusions from maps—have all been tested previously and used widely throughout this book. Indeed, you couldn't have reached this section if you hadn't been able to do all these things. Similarly, your ability to interpret photographs should be well developed by now.

This doesn't mean that you have nothing more to learn except a mass of facts. The ability to add numbers, for example, is useless if you don't know when to use it. Similarly, geographical skills are of little value if you don't know which skill to use in a certain situation.

You will now be given two sets of data with some gaps that should be obvious. These gaps can be filled by your teacher if you ask the right questions. If you don't ask the right questions, you won't obtain the information.

One set of data relates to a farm in North Carolina, U.S.A., the other set to a factory in Geelong, Victoria.

These are the activities you should be able to undertake by applying analytic skills to the farm and factory data:

1. Construct a systems diagram of both the farm and the factory (see studies 1 and 14).
2. Make a map of the site of the farm and the factory and name the functions of the various parts of the system. (This will test whether you can identify various parts of the farm and the factory system from photographs, maps and descriptions.)
3. Try to explain the layout of the farm and the factory in terms of:
   (a) the nature of the site;
   (b) the types of activities.
4. Determine whether the uses to which men are putting the site are suitable in terms of:
   (a) the systems of the drainage basin (studies 23 and 24);
   (b) the effect of the site on men (study 22);
   (c) the effects of the activity on men and on the site.

Figure 26.1: Location of the farm in North Carolina

Figure 26.2: Farm outline showing fences, creeks, dams and roads. Calculate the map scale

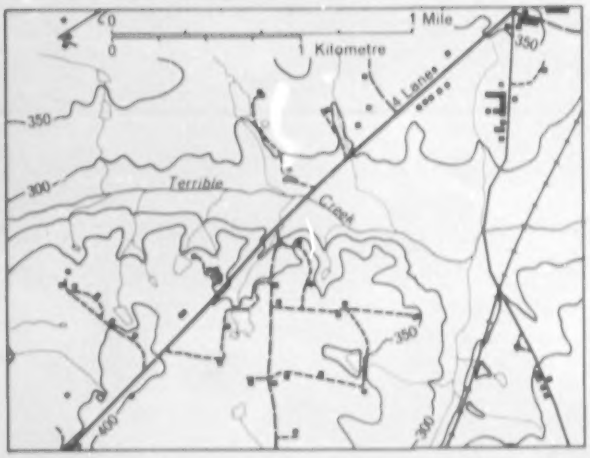


Figure 26.4: Map of farm area (contours in feet)

Figure 26.5: Barns on the farm

Figure 26.6: A tobacco barn on the farm

Figure 26.7: An electric fence on the farm

Figure 26.8: Hogs on the farm

Table 26.1: Land use on farm

Use	Area (acres)
Tobacco	15
Grazing hogs and horses	5
Corn	25
Fallow for rotation	40
Woodland	42
Oats	12
Total	139

The farm

A. Location—see figure 26.1

B. The actual farm—figure 26.2
—figure 26.3, vertical aerial photograph
—figure 26.4, map of the area
—figures 26.5–26.8, photographs of some aspects of the farm

C. Land use—table 26.1.

This data gives you some idea of the farm; you will have to ask your teacher questions to find out further details of the farm system.

The factory

A. Location—see figure 26.9

B. The actual factory—see figure 26.10 (examine the photograph carefully, as it reveals evidence of input and output and the modes of transport)

C. The site—see figure 26.11

D. This factory is No. 1 in table 15.7 and figure 15.2.

This data gives you some idea of the factory; you will have to ask your teacher questions to find out further details of the factory system.

If you have been able to carry out these activities, you have understood a great deal of the ideas contained in Level Three. Also, within each of the studies in this book, and especially at the ends of studies, there were questions and activities; if you

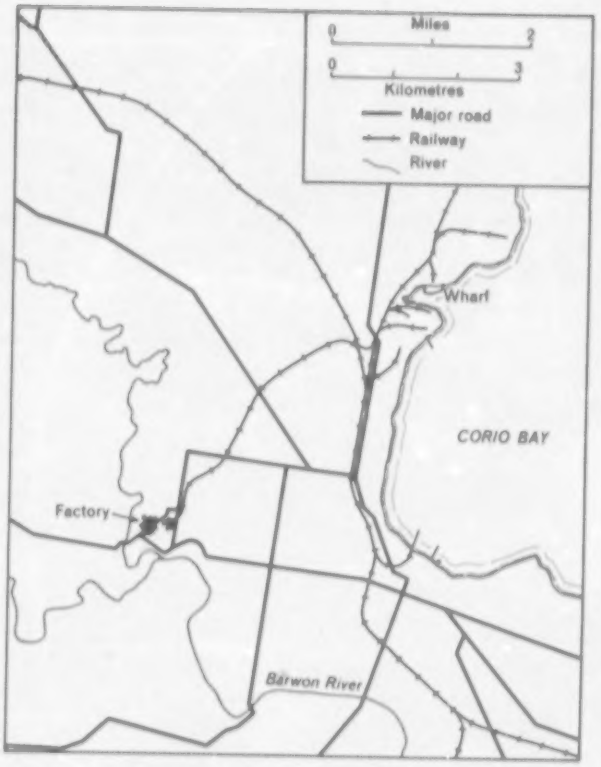
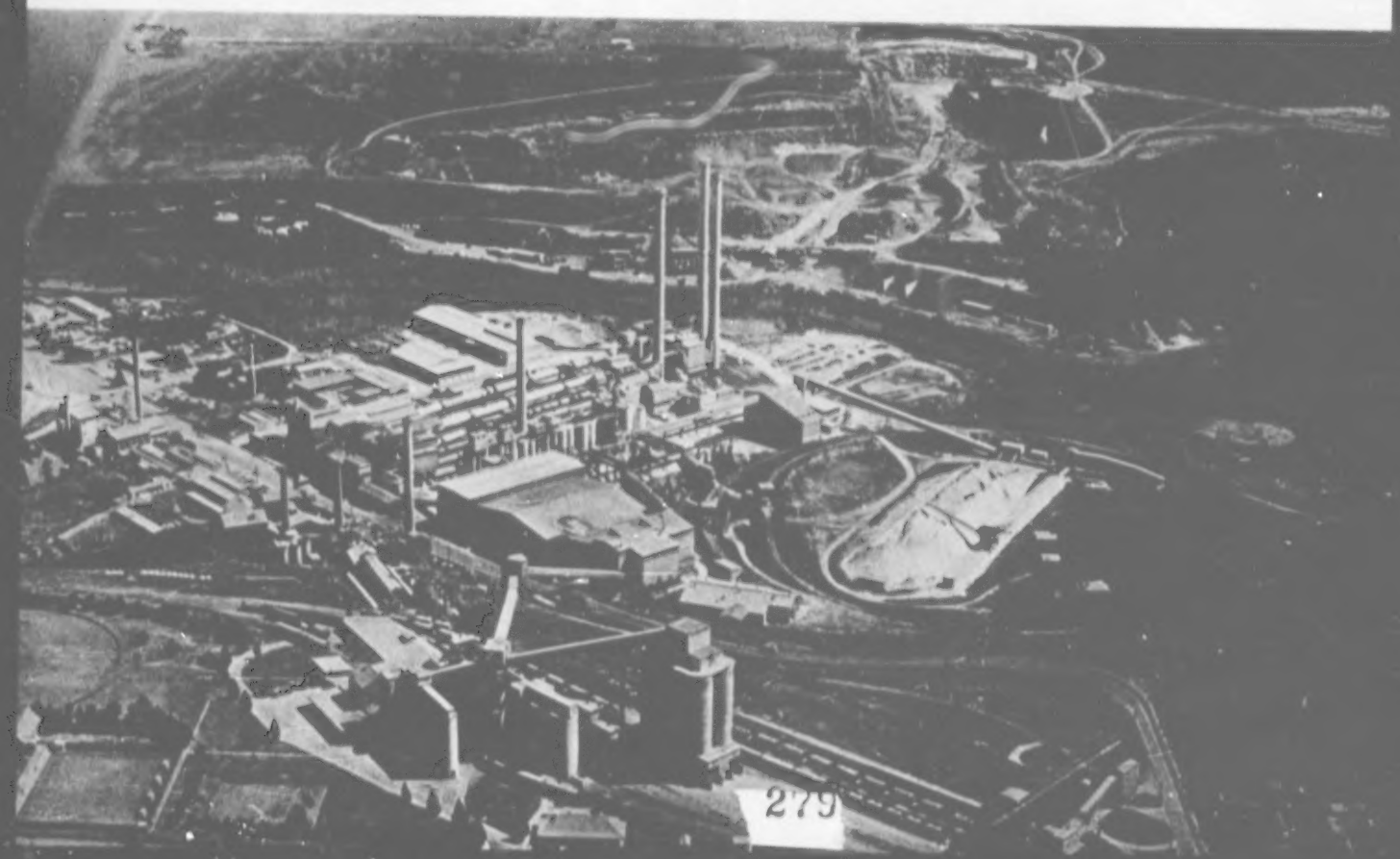


Figure 26.9: Location of the factory in Geelong

Figure 26.10: Fyansford cement works and quarry, looking west



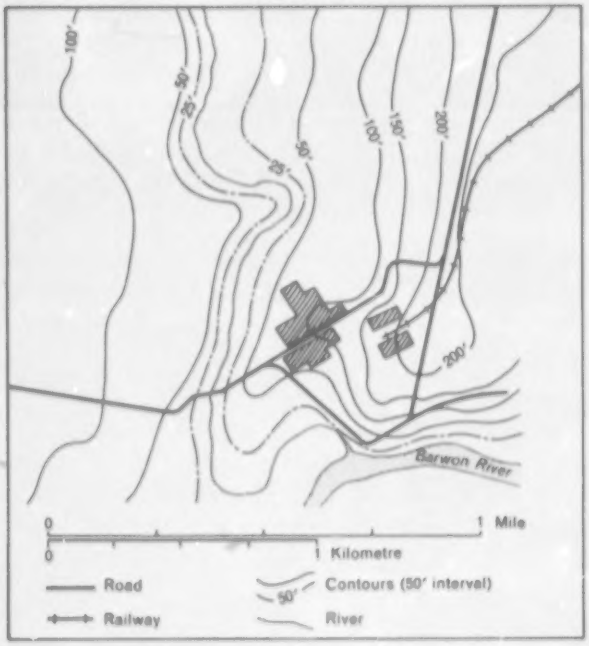


Figure 26.11: Site of the factory (contour intervals in feet)

handled these successfully, you have demonstrated that you have developed to a high level your ability to think.

As our understanding increases, the vocabulary we use expands. As a result of working through Level Three, you should understand the meaning of a number of new terms. This doesn't mean you must learn a definition that is the 'right' one, but you should feel certain you could use the term sensibly and accurately.

Do you understand what these terms mean?

system
drainage basin
watershed
commercial
subsistence
indigenous
expatriate
leaching
soil horizon
gradient
soil erosion
irrigation
land class
subsidence

Examine figures 26.12 and 26.13, maps of the river patterns in two drainage basins. (The basins are at the same scale.)

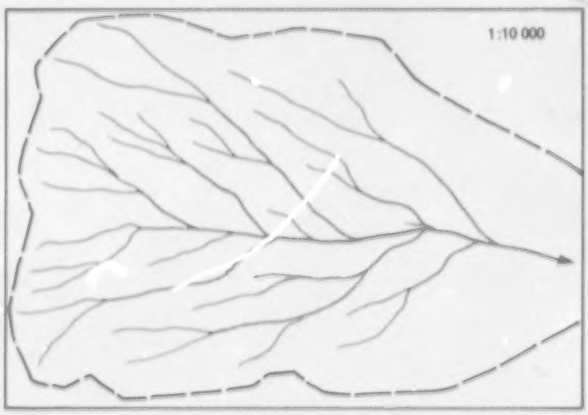


Figure 26.13: Drainage basin B

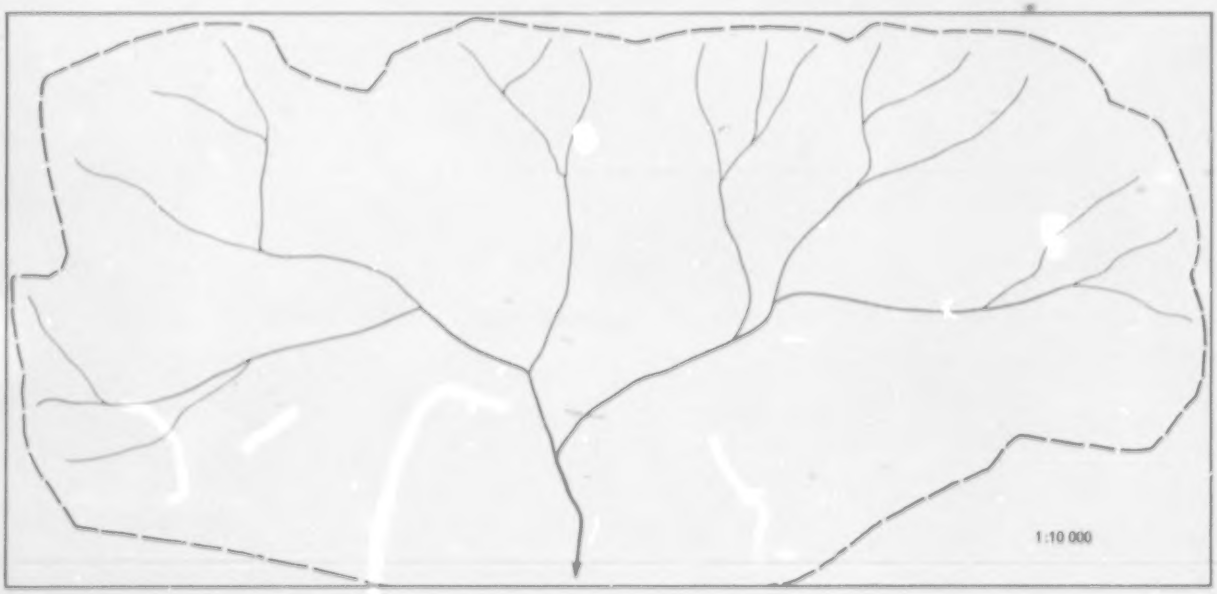


Figure 26.12: Drainage basin A

1. What are the differences between the two basins?
2. What are all the factors that *might* have caused these differences? (Explain the mechanism.)
3. The run-off of drainage basin A is three times that of B, but the run-off of B contains one-and-a-half times the amount of silt in that of A. What are all the factors that *might* cause these differences? (Explain the mechanism.)
4. It has been announced that the government has decided to allow farmers to clear natural vegetation and farm the land in drainage basin A. What could happen in the basin, and why? What precautions would you want to take in the upper reaches, on the plains beside the river in lower areas, and anywhere else in the catchment? How would these precautions be effective?

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